

Delaware Statewide Forest Assessment

1. Introduction

Forests have played an integral role in Delaware throughout its history – from pre-European settlement through the Revolutionary and Civil Wars to today. It is the responsibility of the Delaware Forest Service and its partners to ensure that forests continue to play an integral role in our state's future. To that end, this statewide forest assessment provides an overview of the status of Delaware's forests – both rural and urban, public and private – as well as the many benefits they provide.

This assessment includes the following:

- The conditions and trends affecting our forests
- The benefits and services provided by our forests
- Issues, threats, and opportunities facing our forests
- Priority forest landscape areas identified through the assessment process

Much of this information is presented using the seven criteria of forest sustainability, endorsed by the United States and 11 other countries in 1995 through the effort known as the Montreal Process and adopted by the state foresters of the 20 northeastern states and the District of Columbia. The Delaware Forest Service used these same criteria to present an overview of our forest health in 2005.

The seven criteria address all aspects of forests and their management – both biological and social – specifically, biological diversity, productive capacity, forest health, soil and water resources, carbon cycles, social aspects, and legal and economic issues. There is at least one indicator that helps to present the data within each criterion.

Regarding data, the data used for this assessment were gathered from a variety of sources [Appendix ?]. When possible, data from multiple time periods were used to demonstrate trends; however, such data was not always available. Additionally, there are some metrics for which Delaware has no valid data and these instances are noted within the document [list of gaps in Appendix?].

Furthermore, this assessment considers all forests throughout the state. For instance, this process included both rural and urban forests as well as public and privately owned forests. Analysis of all of Delaware's forests was necessary in order to present a thorough assessment.

Lastly, this assessment was completed by staff within the Delaware Department of Agriculture, Forest Service (DFS) in consultation with a variety of stakeholders and with the guidance of our Forest Stewardship Committee [Appendix for Stakeholder Involvement]. While DFS staff wrote this document, we have attempted to capture the input and recommendations of all our stakeholders.

2. *History*

Delaware's forests have evolved considerably from the virgin acres of oak and hickory that greeted its early Swedish settlers in the 1600s, and provided them with rich timber harvests for ship building, charcoal making, farming and settlements. It is believed that virtually all of Delaware's uplands (excluding marshland) were forested at the time of European settlement. Today, forests cover approximately one-third of Delaware with the remainder cleared for agriculture and then residential and commercial development. These forests, and their perpetuation, are equally as vital to the future of Delaware as our past forests are to our state's history.

Before the arrival of Europeans, the peaceful Lenni Lenape Indians gathered food, game, and crude building materials from the forest. In 1610, an English sea captain whose ship was blown off course into a bay which he named De La Warre, saw huge trees of oak and hickory lining the nearby shore. Early Swedish settlers, in their colony of New Sweden in northern Delaware in the early 1630s, told of the great expanse of nearby timber suitable for framing and "planking." They hand-split, with maul and wedge, the abundant native timber to build their forts and unique log cabins. As soon as sawmills were erected on the many streams flowing eastward to the Delaware Bay, rough boards were cut and shipped back to Europe, along with oak barrel staves and cedar shingles. Tree bark for the medicines of the day, along with the bark of the black oak for tanning, were subsequently shipped to England as that country gained control of the settlements in this new and challenging land in 1664.

With the refinement of streamside sawmills, lumber was cut from the plentiful oaks, pines, and cypress for the building of ships to haul the new colony's bounty. In return, the new settlers sought iron, nails, sugar, seeds, cloth, and Indian trade goods from the outside. History books relate that most of the small rivers heading toward the bay could support a sailing ship of 50-100 tons. In later years, Delaware-built wooden ships would carry charcoal, local produce, furs, iron ingots, marsh hay, and passengers up and down the Delaware Bay. It followed that new towns would spring up around the sawmills, gristmills, shipyards, and loading docks. This was the genesis of many of today's river towns of Delaware, including Wilmington in the north, Frederica, Milford, and Milton in the east, and Seaford, Bethel, and Laurel in the west.

As towns grew, so did the demand for wood. It was needed for building construction, crates, boxes, wharves, and many other uses. Allied industries, such as charcoal-making to smelt the bog iron, developed, and the charcoaling business lasted over 100 years. Evidence of old charcoaling sites can be found in several locations of the state to this day. (As late as early 1950s, a kiln making tinner's charcoal operated in lower Delaware). Carpenters, shipwrights, wheelwrights, and wagon makers plied their trades, and the new railroad spanning the state from north to south in the 1850s needed oak ties from Delaware woodlands.

As the demand for wood products rose at the turn of the new century, dozens of small to medium-sized sawmills, now fueled by steam (later by electricity), went to work in earnest on the seemingly inexhaustible supply of the state's timber resources. Wood production rose to a high of 55 million board feet in 1909 and dropped to a low of 5.2 million board feet in 1918, notwithstanding a high demand for wooden boxes, crates, and baskets for overseas food shipments. Thereafter, another boom cycle began as numerous "basket wood" and "spoon wood" mills flourished until the early 1950s, producing a variety of machine-made products for Delaware agricultural goods. The species most in demand for this use were the "sweet" woods – sweetgum, yellow-poplar, and maple. Box and basket-making machines exist today only in personal collections and local farm museums, their output replaced by that of the plastics industry.

Wood production increased again until a peak in the mid-1950s. Production fell again in 1970, but has gone through many cycles and is presently stabilized (1999) at approximately 14.4 million board feet annually. This production is divided into 46 percent softwood, and 54 percent mixed hardwoods. In addition to saw timber, considerable amounts of pulpwood, primarily pine, are harvested annually in Delaware. Logs for veneer, including plywood and specialty veneer stock (white oak, red oak, and yellow-poplar) command a steady market, both locally and overseas. Piling remains an important and highly sought-after product of the First State's woodlands, particularly from the straight boles of our native loblolly pine.

Over the past three decades, Delaware's forest base has appeared relatively stable, with only a four percent reduction in the past 30 years. A closer look, though, shows that the species composition of Delaware's forestlands is changing from high value upland hardwoods and loblolly pine to lower quality bottomland hardwoods. In addition, with increasing population pressures, the ownership of the forestlands is becoming increasingly fragmented. A major new transportation route has been completed, greatly increasing Delaware's accessibility to metropolitan areas such as Philadelphia and Baltimore. This new transportation corridor will certainly cause an increase in forestland fragmentation.

Currently Delaware is approximately 30 percent forested with 371,000 acres of forestland. Ninety seven percent of the timberland is classified as commercial timberland and can provide sawtimber, pulpwood, veneer, and pilings. Biomass may also be a strong future use of the forests. In Delaware, timberland is also valuable for wildlife habitat, recreation, soil protection, water quality and quantity as well as aesthetics.

The importance of forests to watershed integrity has been documented time and time again. Therefore, forest management is becoming an increasingly popular and effective tool for managing both surface and ground water resources. Delaware has a vast array of these resources and forest management is and shall continue to be a primary means of protecting them.

Delaware has many unique natural areas and is a key location on the Atlantic Flyway for migratory birds. Forestlands are the base for many of these natural areas and unique wildlife habitats. Fragmentation and poor forestland management can seriously threaten wildlife habitat and unique natural areas.

Delaware's third timber resource report was completed in late 1999. Estimated commercial forest acreage of Delaware is presently 376,000, which is less than that shown in the 1957 resource report. Other trends in forest growth are an increase in growing stock volume to 696 million cubic feet, and a decrease in the state's loblolly pine/shortleaf pine group from 49 percent to 19 percent of total forestland. (1999 Delaware Forest Inventory – see Table 3 later in this document)

3. *Forest Conditions and Trends*

Criterion 1: Conservation and Biological Diversity

Importance: Biological diversity includes both the number and the species of plants and animals, as well as their genetic composition. Generally, greater diversity is desired because there is a greater potential to adapt to changes. To protect biological diversity, there must be a sufficient amount of habitat available for animal and plant species to thrive. Conservation of forestland, including the entire range of forest ecosystems, is one step to ensuring biological diversity.

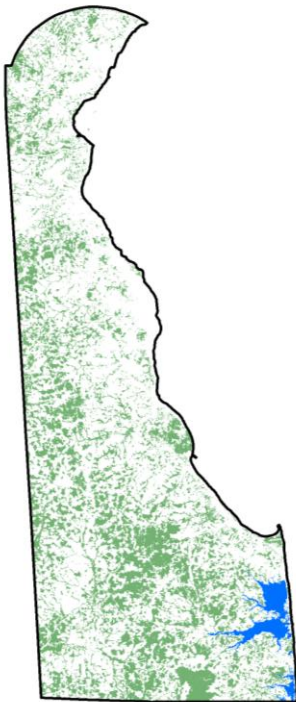
Indicator 1: Area of total land, forestland, and reserved forestland.

Introduction: This Indicator assesses the percentage of the State that is forested, and the percentage of the forested area that is protected from development. The amount of forestland relative to other cover types provides an initial impression of the importance of the resource. The amount of protected forest indicates the degree to which the resource is sheltered from mismanagement or clearing for development.

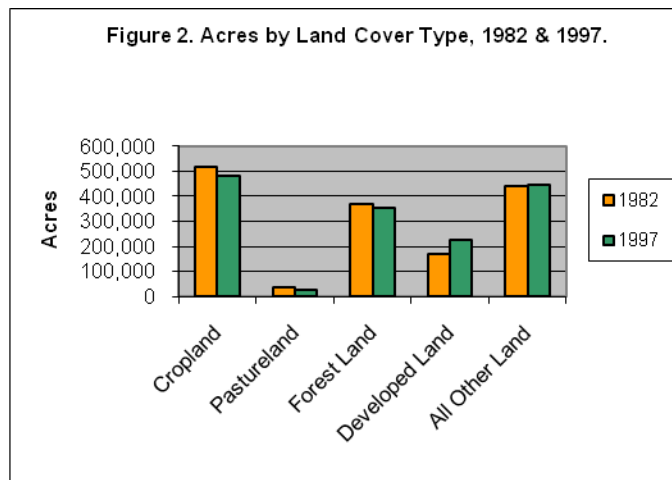
Total Land and Forestland in Delaware:

Delaware contains approximately 1.25 million land acres, of which 371,000 are forested (Figure 1). The definition of forest used to determine forest acreage includes traditional, non-urban areas with forest cover. It does not include forested areas in urban and suburban settings or very narrow “strips” of tree cover such as hedgerows in agricultural fields.

Figure 1. The Forests of Delaware, 2007.



Cropland, such as soybean and cornfields, occupies approximately 479,000 acres in Delaware. The remaining 388,000 acres are a mixture of urban and suburban areas, marsh, pasture, and open water (Figure 2).



Source: USDA NRCS National Resources Inventory and Assessment Division, 2005.

As in other eastern states, the forested area in Delaware has declined considerably since European colonization in the 1600s. The natural land cover on all but the wettest sites is forest, so during pre-colonial times forests covered approximately 1.1 million acres, or 90 percent of the total land area in the state. During European settlement, forests on the most productive and well-drained soils were removed and replaced with agricultural crops.

Delaware experienced its lowest amount of forest cover around the year 1900, with only 350,000 acres forested. Since then, forest area has fluctuated between 370,000 and 450,000 acres during most of the twentieth century (Table 1). This fluctuation was due in large part to patterns in cultivation and abandonment of agricultural fields.

Table 1. Acres of Forest in Delaware.

Year	Acres of Forest (x 1,000)
1907	350
1938	423
1953	454
1963	392
1977	392
1987	398
1997	389
2002	383
2007	371

Source: Smith et al. 2004. *Forest Resources of the United States, 2002*. Gen. Tech. Rep. NC-241 and Delaware Forest Service data.

Urban Forests:

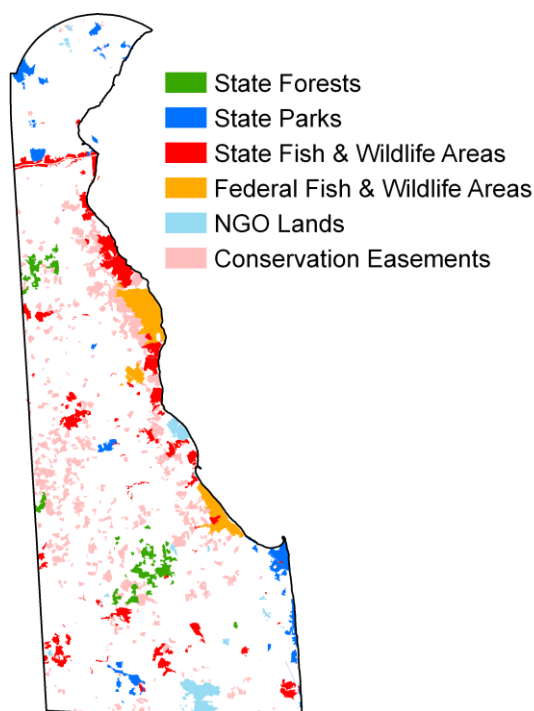
Urban forest (canopy) cover varies greatly within Delaware. The DFS completed a GIS analysis of urban forest canopy using 2007 LIDAR (laser) data with Delaware's 57 incorporated municipalities. Of the 86,713 acres located within municipal boundaries, 15,380 acres (17.7 percent) have urban tree cover. Urban tree cover varies significantly among communities, ranging

from 3.3 to 73.9 percent. When one includes not only the incorporated municipalities but also other urbanized areas designated by the 2000 Census (such as the area of Bear in New Castle County), the total land area within all urbanized areas totals 234,000 acres of which approximately 39,300 acres have urban forest cover, thus Delaware's total urban forest canopy coverage is just under 17 percent.

Protected Forestland:

In total, approximately 100,000 acres, or over one-quarter of Delaware's forests, are protected from development. These lands include government-owned and NGO tracts, as well as areas protected by permanent conservation easements (including over 22,000 acres of forestland protected through easements purchased by the Delaware Aglands Preservation Program) (Figure 3).

Figure 3. State, Federal, and NGO lands.

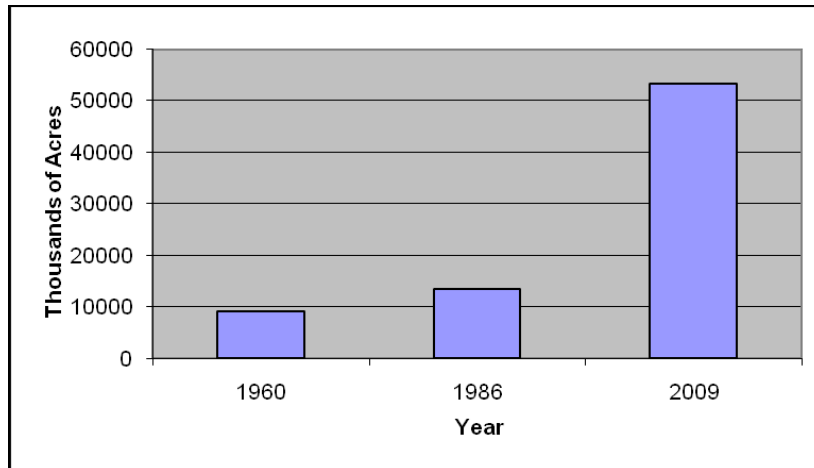


Delaware also initiated a Forestland Preservation Program (FPP) in 2006 to purchase conservation easements on working forestlands, modeled after the very successful Aglands Preservation Program. With an initial allocation of \$1 million in FY08 along with \$500,000 from The Nature Conservancy, conservation easements were purchased on 9 tracts totaling 835 acres [Appendix for description of FPP]. The DFS, working with The Nature Conservancy and other partners, continues to seek additional funding for the FPP.

Furthermore, Delaware has enjoyed much success through the Forest Legacy Program. Through FY10, Delaware has received \$14.925 million for the multi-phased Green Horizons project. Since 2000, through a combination of Forest Legacy, state Open Space, county, and NGO funds, Delaware has protected over 16,000 acres of industrial forestlands (approximately 3,000 acres through Forest Legacy) through fee simple and conservation easement purchases.

These purchases have produced a significant increase in the amount of forestland owned by state agencies since 1960. Much of this increase resulted after the passage of Delaware's Land Protection Act, which established the state's Open Space program and a permanent funding source for land acquisition. Since its inception in 1991, Delaware's Open Space program has protected over 50,000 acres at a total cost of \$291 million (\$229 million of state funds). Figure 4 demonstrates this increase in protected lands.

Figure 4. Protected Forestland



Source: USDA Forest Service Forest Inventory and Analysis and State Agency reporting.

None of Delaware's forests are in areas specifically designated as "Reserved," meaning no timber harvest is allowed. However, about 28,000 acres are owned and managed by non-governmental organizations (NGOs) or the State Park System, where silvicultural activities generally are not practiced.

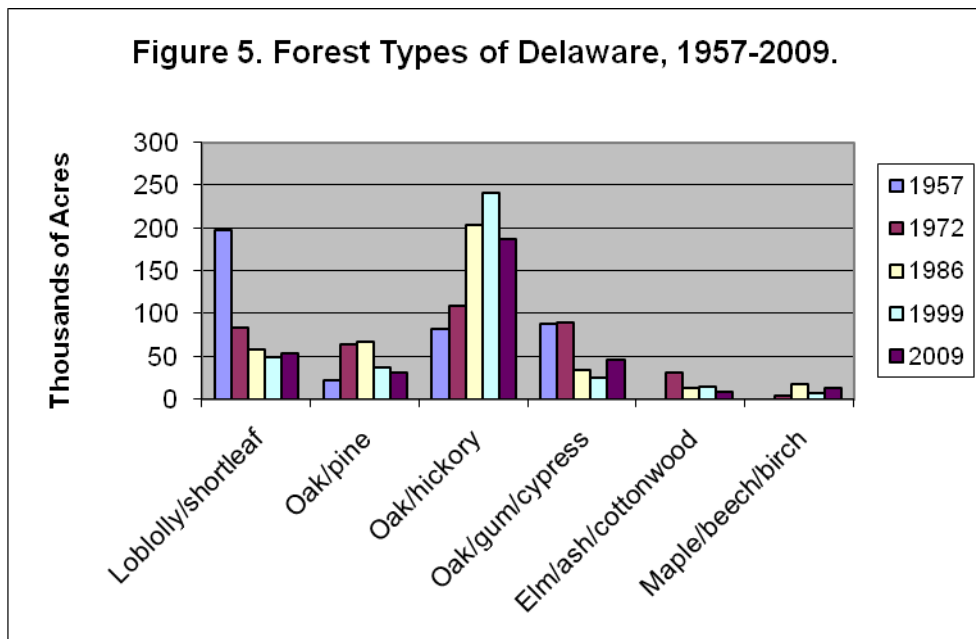
Conclusions: Delaware has lost over half of its forests since European settlement. This loss stabilized around 1900 and Delaware's forestland area actually increased in the early 20th century; however, recent development has again resulted in a loss of forestland. Currently, approximately one-third of the state is forested, and forests are a significant resource. Delaware recognizes the importance of its forests and has taken action with its partners to protect them. To date, 100,000 acres of forestland have been protected through either conservation easements or fee simple acquisition. Delaware also established the first state-funded program in the nation specifically designed to purchase conservation easements on working forestlands. It is crucial that Delaware continue these efforts to ensure sufficient forestland is protected to maintain all of the functions and benefits our forests provide.

Indicator 2: Forest type, size class, age class, and successional stage.

Introduction: This indicator provides a view of the overall forest resource in the State. Periodic forest inventories are used to develop reports that describe the basic biological characteristics of our forests and the trees they contain. Ideally, the state's forest resource will contain a mixture of native forest types and, within each type, there is a balance of tree size and age classes.

Forest Types in Delaware:

Forestland within a state or region is often classified by type – that is, the common dominant tree species or combination of tree species found in those forests. Delaware's forest types are based on inventories by the U.S. Forest Service through its Forest Inventory and Analysis (FIA) program. More than half of the forested area in Delaware currently consists of an oak-hickory complex (Figure 5). Pine and oak-pine types comprise approximately one fourth of the total area. Minor hardwood components (gum, maple, etc.) occupy the remaining 15 percent of the forested acreage.



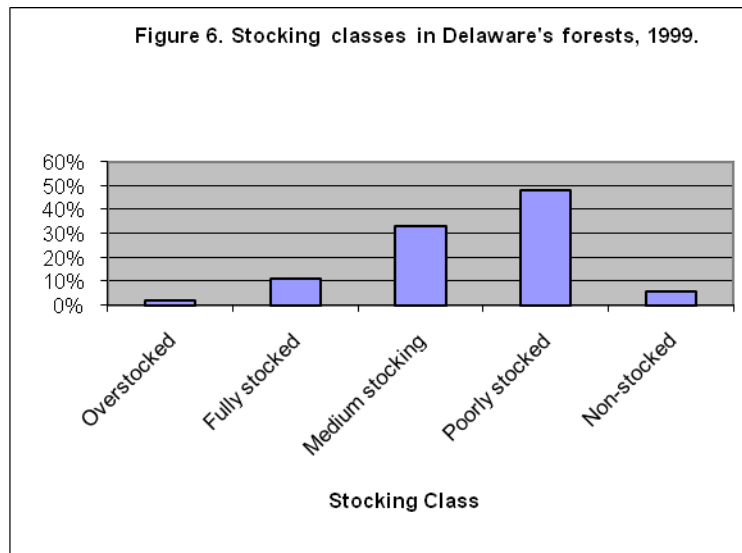
Source: USDA Forest Service Forest Inventory and Analysis.

While the total area of forestland has remained relatively stable over the last 50 years, significant changes have occurred within Delaware's forests. Notably, loblolly pine has steadily decreased in acreage, from nearly 200,000 acres in the 1957 FIA inventory to only 54,000 acres in 2009. Much of this decline occurred between 1957 and 1972 when significant areas of woodland were cleared for agriculture and before Delaware's Seed Tree law. This 75 percent decline is significant because loblolly pine is one of Delaware's most important commercial timber species and historically contributed considerably to Delaware's economy. The passage of Delaware's Seed Tree law in 1989 was due to this precipitous loss in loblolly pine forests and requires landowners to ensure that harvests of loblolly pine (and yellow-poplar) forests greater than 10 acres are sufficiently regenerated. This law only applies to properties that will remain in forestland (does not apply to land use changes, such as development).

The decline of loblolly pine is due, at least in part, to trends in growth and removals. Since 1959, removals of softwood growing stock have consistently exceeded growth, while hardwood growth exceeds removal of hardwood growing stock. In many cases, natural regeneration by hardwoods

such as oaks and hickories after a loblolly pine harvest results in a hardwood stand replacing a former pine stand. Since 1959, the oak-hickory type has more than doubled from 80,000 acres to 191,000 acres.

Delaware's forests contained more than 263 million trees in 1999. Stocking, a measure of the number and size of trees on each acre of forest, was sufficient on only about half of the forestland in the State (Figure 6). Many acres were classified as poorly stocked because there were not enough trees present to fully occupy all available growing space. This condition could be due to several factors, but many areas naturally have sparse forest cover due to low-lying topography and very wet soils. The gypsy moth, which was first detected in Delaware in 1979, severely impacted oak forests throughout the state, and as a result, many of these forests are now under-stocked and/or have experienced a significant change in species composition from oak to maple and gum.



Source: USDA Forest Service Forest Inventory and Analysis.

Total volume of all trees was 863 million cubic feet (Table 2). Growing stock, by definition, does not include non-merchantable species or trees that are unmarketable due to defects. Approximately 95 percent of total volume is marketable and therefore is included in growing stock volume.

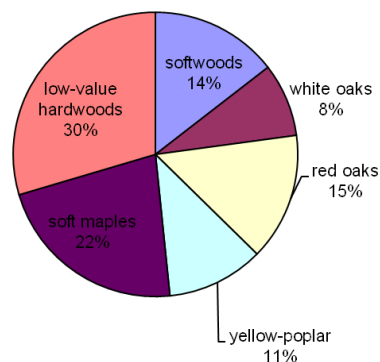
Table 2 - Wood Volume by Species Groups

Species Group	Volume (thousand Cubic feet) Growing Stock
Loblolly and shortleaf pine	98,294
Other yellow pines	24,841
Other eastern softwoods	1,592
<i>all softwoods</i>	<i>124,727</i>
Select white oaks	70,760
Select red oaks	10,435
Other white oaks	1,246
Other red oaks	114,656
Hickory	6,010
Soft maple	189,720
Beech	12,266
Sweetgum	114,517
Tupelo and blackgum	33,821
Ash	18,923
Cottonwood and Aspen	1,436
Yellow-poplar	94,652
Black walnut	5,355
Other eastern soft hardwoods	38,763
Other eastern hard hardwoods	23,321
Eastern non-commercial hardwoods	1,945
<i>all hardwoods</i>	<i>737,826</i>
Total	862,553

Source: USDA Forest Service Forest Inventory and Analysis.

Figure 7 shows the breakdown of growing stock by major species group. Hardwoods accounted for about 86 percent of total volume. Red and white oaks, which are valuable trees for lumber as well as wildlife, made up about one-quarter of hardwood volume.

Figure 7. Total volumes by species, 2008.



Source: USDA Forest Service Forest Inventory and Analysis.

Roughly half of all volume consisted of red maple and other low-value hardwoods. The abundance of low-value hardwoods is due to a combination of factors, including oak mortality from gypsy moth infestations in the late 1980s and early 1990s, damage from the 1994 ice storm (particularly pine forests), and improper timber harvests. Poor timber harvests have resulted in pine forests regenerating to low quality hardwood forests and the high-grading of hardwood forests (removing only the best species and specimens) that result in increasingly poorly stocked forests. One reason for the occurrence of poor hardwood management is the lack of markets for small-diameter and low quality hardwood. Proper management of these stands and increased markets for low value hardwood in the future could shift species composition back in favor of oak, yellow-poplar, pine, and other valuable species. Development of new markets for low-value hardwood products could facilitate proper management.

Conifers accounted for approximately 14 percent of all live tree volume in the State. Loblolly pine comprised about 90 percent of conifer volume, with Virginia pine, baldcypress, and Atlantic white-cedar accounting for most of the remaining volume. The amount of baldcypress and Atlantic white-cedar have declined due to timber harvests and increased drainage – through both the draining of wetlands and the channelization of streams.

Forest Age and Size Classes:

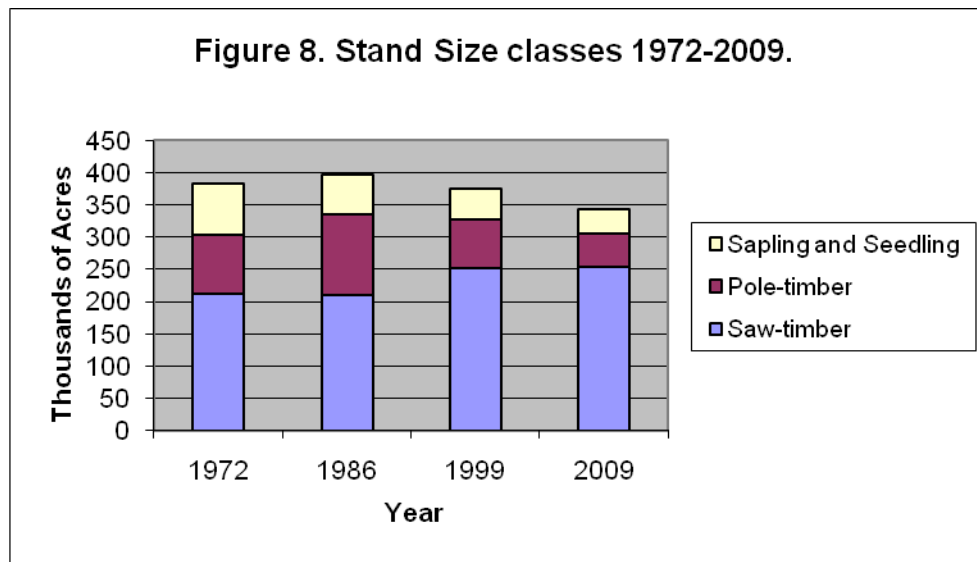
Total growing stock volume has increased by 60 percent since 1957 (Table 3). However, softwood and hardwood totals have not changed equally over this time period as would be expected with the aforementioned change in forest types. Softwood growing stock has declined by nearly one-half while hardwood volume has more than doubled. These changes serve as another indication of the reversion of many pine stands to hardwood stands following timber harvest, a phenomenon discussed previously in this section.

Table 3. Volume of Growing Stock, 1957-2009.

	Volume (Million Cubic Feet)				
	1957	1972	1986	1999	2009
Softwoods	230	184	164	115	120
Hardwoods	273	403	496	581	690
Total	503	587	660	696	810

Source: USDA Forest Service Forest Inventory and Analysis and
USDA Forest Service Resource Bulletins NE-109 and NE-151.

Sawtimber stands accounted for the majority of the forested acreage in the State in 2009 (Figure 8). The remaining forest is divided almost equally between pole-timber stands and sapling/seedling regeneration. Since 1972, as average diameter has increased, more stands have fallen into the sawtimber size class with a corresponding decrease in the area of seedlings and saplings. This represents an “aging” of Delaware’s forests with a greater portion in older, larger size classes. In 1972, just over 50 percent of our forests were considered sawtimber size while today this percentage has increased to approximately 65 percent – a 30 percent increase. This is likely due to the changing dynamics of forest ownership, with the dwindling holdings of forest industry, more owners with smaller tracts who do not harvest timber, and a greater number of publicly owned forests.



Source: USDA Forest Service Forest Inventory and Analysis and
USDA Forest Service Resource Bulletins NE-109 and NE-151.

While having larger, older timber is appealing for some reasons (these forests have the appearance of what many people envision as typical forest), having the majority of your forests in one age group is a concern. We need a balanced mixture of not only tree species but also forest ages. Younger forests are needed to replace older forests that are lost to harvesting, natural mortality, or catastrophic events (hurricane, ice storm, etc.). Seedling and sapling forests also provide habitat for certain wildlife species, such as woodcock. Future efforts should include continued monitoring of the age of Delaware's forests and working to ensure that our forests maintain a balance of species and age diversity.

***Conclusions:** While Delaware's overall forest base has remained relatively constant over the past century, significant changes have occurred in the forest's composition. An oak-hickory forest type now covers more acreage than any other type in Delaware while loblolly pine forests have decreased by 75 percent (most of this decline occurred in the 1960s and 1970s). About half of all growing stock volume consists of red maple and other low-valued hardwood timber species, which are minor components of all types. This is a fundamental change since 1957, when about half of all growing stock was loblolly pine and other softwoods. Furthermore, Delaware's forests are aging and growing in size. Nearly 2/3 of the state's forests are now classified as sawtimber and less than 25 percent are seedlings and saplings. These trends are a concern as it is important to maintain a balance of forest types and tree sizes and ages within each forest type.*

Indicator 3: Extent of forestland conversion, fragmentation, and parcelization.

Introduction: While it is important to study the amount of forestland within a state or region, it is also necessary to understand the rate at which forests are lost through conversion to other land uses, namely agriculture, which may be temporary, or development, which is almost always permanent. Also important is the degree to which the remaining forest is fragmented, or broken into smaller contiguous blocks. Forest fragmentation leads to additional challenges that degrade forest health and sustainability. Invasive plant species that displace native plants often become established around forest edges and reduced forest parcel size results in less interior forest for plants and animals that require this specific habitat. A third concern is the reduction in the average forest ownership size (parcelization) as large parcels are subdivided into multiple ownerships. The resulting increase in the number of forest landowners requires more technical forestry assistance to manage the same forested acreage and makes large-scale forest management more difficult.

Forest Conversion:

As discussed in indicator 1, Delaware's forested acreage has remained relatively constant over the past century. In fact, Delaware has more forestland today than it did in 1909; nonetheless, our forested acres have decreased since 1950. The initial losses in the mid-late 20th century were primarily to agriculture; however, this conversion has slowed dramatically (and, in fact, with the advent of the Conservation Reserve Enhancement Program – CREP – the loss of forestland through conversion to cropland has basically stopped with the planting of over 3,800 acres of cropland to trees through CREP). While the loss of forestlands to agriculture has virtually ceased, the conversion due to development has rapidly increased over the last two decades.

Land values have increased substantially throughout Delaware since the late 1980s, in some cases 20 to 30 fold. As a result, many large forest parcels have been subdivided and developed. A study by the Delaware Forest Service (DFS) found that between 2002 and 2009, nearly 16,000 acres of Delaware's remaining 217,000 acres of unprotected forest (privately owned without a permanent conservation easement) were contained within areas approved for development. While the pace of development has slowed dramatically since 2006, this loss of forestland is a significant concern. Unlike a change from forest to agriculture, where the area may return to forest in the future, development represents a permanent reduction in the forestland base.

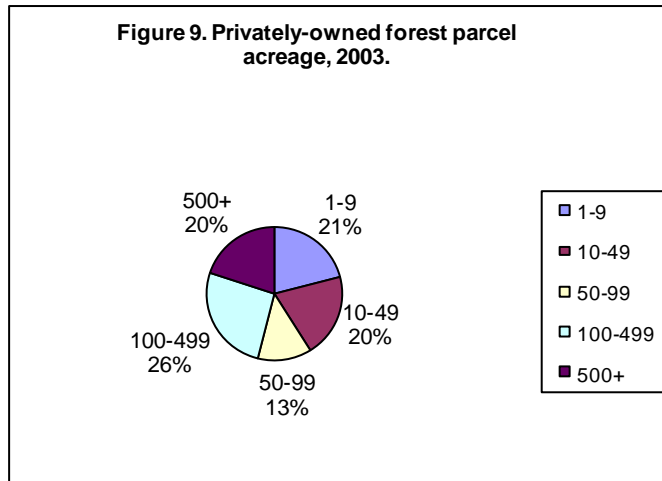
Forest Fragmentation:

With the recent decrease in forestland has come a corresponding increase in forest fragmentation (smaller areas of contiguous forests). An analysis by the DFS compared forest cover in 1937 and 2002 using aerial photographs and Geographic Information Systems (GIS) software. Of the acres that were forested in 1937, approximately 72 percent were also forested in 2002. Many of the areas that remained as forests were harvested during the intervening 65 years; however, the land remained in forest as stands were replanted or regenerated naturally. The other 28 percent of the forested acreage was cleared for other land uses during the intervening period. Of course, some areas that were not forested in 1937, particularly some agricultural fields, were forested in 2002. Nonetheless, this study demonstrates both forest conversion and fragmentation.

[Insert paragraph on GIS analysis of 250+ acre forested blocks in 1937 vs. 2002]

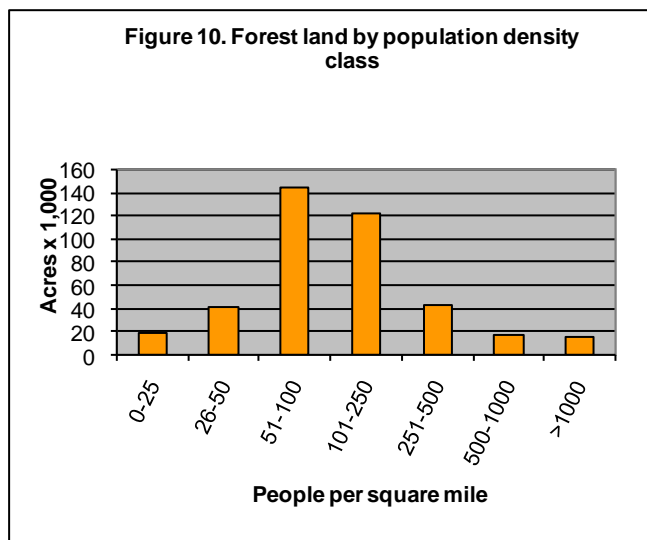
Forest Parcelization:

As with forest size, the average forest ownership is also decreasing. The average size of privately owned forest parcels in 2003 was 9.5 acres in the mid-Atlantic region, which includes Delaware, Maryland, and New Jersey; the average forest parcel in 1975 was 32 acres, indicating that there are more owners with smaller woodlots today than there were 35 years ago. Additionally, as shown in Figure 9, 41 percent of forest ownerships were less than 50 acres and only 20 percent of all parcels were 500 acres or larger.



Source: US Census Bureau and US Geological Survey.

Two-thirds of Delaware's forests are located in areas with population densities between 51 and 250 people per square mile (Figure 10).



Source: USDA Forest Service Forest Inventory and Analysis.

Delaware's 2002 population was 806,105, so the average population per square mile statewide is slightly more than 400 people. This compares to a population of 666,168 in 1990 – a 21 percent increase in only 12 years. Furthermore, Delaware's population is becoming less concentrated within municipalities and is spreading across the landscape. In 1920, 49 percent of Delaware's population lived within Wilmington, its largest city; today, only 9 percent of our population calls

Wilmington home. A study by the American Farmland Trust (AFT) found that between 1984 and 2002, 118,000 acres of farms and forests were consumed by 96,000 residential housing units (1.23 acres per house) – nearly equal to all of the acres consumed in the previous 300 years. Prior to 1984, the state's 260,000 housing units consumed 125,000 acres of land (0.48 acres/house). Thus, Delaware's population is not only increasing but also using more land for each new house; this trend is unsustainable.

Currently, urban areas have displaced approximately 13 percent of Delaware's forests. A recent study estimated that by 2050, 43 percent of Delaware's forestland will have been subsumed by urban growth. In other words, in the year 2050, almost half of Delaware's former forests will lie within the limits of new urban areas. Only four other states are expected to experience a greater degree of absorption of forest into expanding urban areas (Source: Nowak et al, 2005. *The Increasing Influence of Urban Environments on US Forest Management*. Journal of Forestry, December 2005).

Urban Forests:

As expected, as the amount of rural forestland decreases and fragments, Delaware's urban forest area is increasing. While there is no accurate data of the past amounts of urban forests, using GIS analysis of aerial photographs, the DFS estimates that there are nearly 40,000 acres of urban forests located within Delaware's 57 incorporated municipalities and other urbanized areas designated by the 2000 Census. The total land area within these urbanized areas totals 234,000 acres, thus Delaware's urban forest canopy coverage is just under 17 percent.

Conclusions: While Delaware has more forestland than it did a century ago, the loss of forestland has increased significantly in the past 20 years, primarily due to development. This loss of forestland has also produced increased fragmentation and an increasing urban forest component. Furthermore, the average woodland parcel size is less than 10 acres – an all-time low – and, on average, new houses are using an increasing amount of land. While the recent economic downturn and resulting depressed real estate market have slowed these trends, they are likely to continue in the foreseeable future. These changes present both environmental and economic challenges.

Indicator 4: Status of forest/woodland communities and species of concern.

Introduction: Forests provide habitat (shelter, food, etc.) for numerous animal species and are home to a wide variety of plant species. Some rare plants are found only in specific types of forest, and some rare animals require certain forest habitat for their survival. Protecting and conserving the wide range of forests native to Delaware is vital to the survival of many plant and animal species – both rare and common. Recognizing and understanding the rare, threatened, and endangered species of plants and animals found in our forests is the first step in their conservation.

Delaware Wildlife Action Plan:

The Delaware Wildlife Action Plan (“Plan”), completed in 2006, represents the state’s first attempt to develop a comprehensive strategy for conserving the full array of native wildlife and habitats – common and uncommon – as vital components of the state’s natural resources. It is intended not only to be comprehensive in terms of the species, habitats, issues and actions it addresses, but also comprehensive in terms of those responsible for implementation. Though the Delaware Division of Fish and Wildlife (DNREC) plays a lead role in its continued development and in coordinating implementation, the Plan is intended for all who are actively engaged in conservation efforts. Together with conservation partners, the aim of the Plan is to keep species common, and prevent species from being listed as endangered.

Despite its small size Delaware harbors a diversity of wildlife and habitats within its borders from the Atlantic Ocean coastline to the Piedmont border with Pennsylvania. More than 1,000 species of wildlife have been documented in the state, and more than 125 different types of habitat have been identified including coastal marine waters and brackish marshes, tidal and non-tidal freshwater streams and wetlands, and upland forests and meadows. Of these, the Plan identifies more than 450 Species of Greatest Conservation Need (SGCN) and 50 different types of Habitats of Conservation Concern (HCC). Because this is a comprehensive plan for all wildlife, large blocks of forest and wetland habitats (>250 acres) that support many common species are also identified. Maps depicting habitat for a full array of wildlife (“Key Wildlife Habitats”, which includes large forest and wetland blocks, HCC and SGCN) were created to show areas of the state where conservation efforts can be focused. These maps are also intended to help guide more site-specific conservation planning efforts. A successful example of site-specific community-based planning effort was conducted in partnership with The Nature Conservancy as a subset of the state’s wildlife strategy development (i.e., Blackbird-Millington Corridor Conservation Area Plan).

Recognizing all possible issues that affect species and habitats of conservation concern, whether the impacts are fully understood or not, is an important step in building a comprehensive plan. Nearly 90 different conservation issues affecting species or habitats of conservation concern were identified, representing 16 different categories of issues. To address this extensive list of issues and impacts on SGCN and Key Habitats, more than 230 different conservation actions were developed. This extensive list of issues and actions were prioritized by reviewing several natural resource plans developed for Delaware over the years. As a result, a clear picture of priorities emerged; among themes represented were habitat loss and degradation, including loss and conversion of forest habitat to other land uses.

Forest Communities:

Delaware has a significant variety of forest communities in a relatively small geographic area. Thirty-one forest communities (i.e., tree canopy >60%) and nine woodlands (i.e., tree canopy

<60%) are listed in the *Guide to Delaware Vegetation Communities*¹, which follows the National Vegetation Classification (NVC) System. The NVC classifies vegetation on a national scale for the United States and is linked to the international vegetation classification. The NVC helps provide a uniform name and description of vegetation communities found throughout the country and helps determine relative rarity of different community types.

Some of the rarer forests include the Inland Dune Ridge Forest found in the Nanticoke River area; Southern New England Red Maple Seepage Swamp found in the Piedmont; North Atlantic Coastal Oak-Holly Forest found in the Nanticoke and Choptank River watersheds; Northern Coastal Plain-Piedmont Basic Mesic Hardwood Forest found scattered throughout the state; and the Chesapeake Bay River Bluff Chestnut Oak Forest found in the Appoquinimink River watershed.

Some of the rare woodlands include Central Appalachian/Piedmont Bedrock Floodplain Woodland found in one location in the Piedmont; several woodlands found in the southern portion of the state including Red Maple-Tussock Sedge Wooded Marsh near Millsboro, the Inland Dune and Ridge Woodland/Forest found in the Indian River and Nanticoke River watersheds, and coastal woodland communities like the Maritime Red Cedar Woodland, Loblolly Pine Dune Woodland, and Loblolly Pine-Wax-myrtle-Salt Meadow Cordgrass Woodland. The Pitch Pine Dune Woodland is only found at Cape Henlopen State Park, and the Pond Pine Woodland is found at Prime Hook NWR and at a site near Millsboro.

Loblolly pine forests have decreased significantly over the past 50 years; however, this loss has begun to slow with the passage of the Seed Tree law and the availability of publicly funded cost share programs to assist landowners with reforestation and other forest management expenses. Additionally, many of Delaware's bottomland tree species have experienced substantial declines over the past 40 years due to logging and wide-scale drainage by ditching and stream channelization. Atlantic white-cedar (*Chamaecyparis thyoides*) and baldcypress (*Taxodium distichum*) has experienced significant declines; this loss is evident by the reduction in acres of the oak/gum/cypress forest type where these species are commonly found from approximately 100,000 acres in 1972 to approximately 25,000 acres in 1999 (see Figure 5). The actual total acreage of Atlantic white-cedar and baldcypress trees are much lower than this total. Vegetation communities that these species are found include Coastal Plain Atlantic White Cedar-Red Maple Swamp that occurs throughout the Coastal Plain, Atlantic White Cedar/Seaside Alder Woodland found in the Cedar Creek and Prime Hook Creek watersheds, Chesapeake Bay Cypress-Gum Swamp found in the Nanticoke River and Pocomoke River watersheds, and Wind-tidal Cypress-Gum Swamp found in the Broad Creek watershed. As a further example, the 10,000-acre area known as the Great Cypress Swamp in southern Delaware has virtually no Atlantic white cedar or baldcypress remaining due to logging and ditching. This swamp is thought to have been over 50,000 acres before the arrival of European settlers and subsequent ditching and clearing.

Coastal Plain Seasonal Ponds:

Coastal Plain seasonal ponds, or Delmarva Bay's, are worthy of mention relative to the forested landscape. This unique type of non-tidal freshwater wetland in Delaware supports a variety of state and globally rare plants and animals. Seasonal ponds are found on the landscape within forested areas, and appear as open canopy depressions that are usually elliptic in shape and are about 1-2 acres in size. There are hundreds of these seasonal ponds scattered throughout the state, but they most frequently occur in southwestern New Castle County and northeastern Kent County.

¹ Coxe, Robert. 2009. Guide to Delaware Vegetation Communities-Fall 2009 version. Delaware Division of Fish and Wildlife Publication.

The geologic origins of coastal plain ponds are still unresolved, but the most plausible theory is that Coastal Plain seasonal ponds on the Delmarva Peninsula began forming between 15,000 and 20,000 years ago, when the climate that was much colder and drier. The theory suggests that strong winds created blow-outs, or depressions in unvegetated sandy areas and deposited the sand around the ponds perimeter that often appear as elevated rims. Seasonal ponds are strongly influenced ecologically by fluctuating groundwater levels that rise and fall with the seasons. They are typically flooded in winter and spring when groundwater levels are high, and begin to draw-down during the summer months when precipitation is typically low and evapotranspiration is high. By late summer/early fall, the ponds are dry.

Because of this distinctive regime of flooding and drying, the ecology of Coastal Plain seasonal ponds is a fascinating subject. A number of animals and plants have adapted to life within seasonal ponds and many of these are very rare in Delaware. Because seasonal ponds are not permanent bodies of water, fish are unable to live in them. As a result, state-rare salamanders, such as the Marbled (*Ambystoma opacum*), the Spotted (*Ambystoma maculatum*) and the Tiger (*Ambystoma tigrinum*), as well as state-rare frogs [Cope's Gray Treefrog (*Hyla chrysoscelis*), Barking Treefrog (*H. gratiosa*), and Carpenter Frog (*Rana virgatipes*)], are able to breed and lay eggs in them when the ponds are flooded in the spring. If fish were present, they would eat the eggs and amphibian populations would not be able to survive in these unique habitats. The salamanders previously mentioned actually spend the majority of their lives in the forests and woodlands that surround seasonal ponds. Though the ponds themselves are critical for sustaining salamander populations, the forest surrounding these ponds are just as vital to these animals, providing habitat used during most of their annual life cycle.

There are also several state and globally rare plants that are found in Coastal Plain seasonal pond habitat. In fact, there are 77 native plants that are primarily found growing within seasonal ponds in Delaware, 40 of which are state rare (52% of the total) and six that are globally rare. The feather foil (*Hottonia inflata*) and the water crowfoot (*Ranunculus flabellaris*) are examples of state-rare plants that are entirely dependent on the fluctuating groundwater levels of seasonal ponds in order to complete their life cycles. These species flower at the water's surface when the seasonal ponds are flooded in the spring, and seeds germinate in late summer when they are dry. Without this regime of flooding and drying, these species would not persist. A globally rare plant that occurs in Coastal Plain seasonal ponds in Delaware is the Hirst Brothers' panic grass. This grass is known from only five other seasonal ponds in the world, all in the Eastern U.S.

Forests surrounding seasonal ponds help maintain the ecological integrity of these habitats in many ways. Coastal Plain seasonal ponds are one of the most important non-tidal, freshwater wetland resources in the State of Delaware. They provide habitat to a variety of state and globally rare plants and animals, many of which rely entirely on the unique ecological processes of seasonal ponds in order to survive. In addition, the forests and woodlands that surround seasonal ponds provide habitat for the various amphibian species that use seasonal ponds as breeding sites, and are critical groundwater recharge areas that help to maintain the water regime of flooding and drying that is the driving force behind the ecology of all seasonal ponds. [Text by McAvoy]

Species of Concern:

Of the more than 900² animal species native to Delaware, 87 are historical or extirpated, 298 are rare or uncommon, and the remaining 515+ species are common or status has not been determined.

² This number includes only species associated with terrestrial, freshwater and brackish habitats. Species found in marine habitats and introduced, exotic, and accidental species are not included in this tally. This number (900) is a conservative estimate given the lack of information on many invertebrate groups of animals.

Forty-five of these are listed as State Endangered – 11 of which are forest-dependent species (eight birds, two amphibians, one mammal). Five are protected under the federal Endangered Species Act as threatened or endangered – one is a forest-dependent species (mammal). Of the 459 species (including marine species) listed as “Species of Greatest Conservation Need” in the Delaware Wildlife Action Plan, 120 are classified as “Tier 1” and 339 are classified as “Tier 2”. Tier 1 species are those that are most in need of conservation action in order to sustain or restore their populations. Tier 2 species are also in need of conservation action, although not with the urgency of Tier 1 species. Table 4 tallies only those SGCN found in terrestrial, freshwater or brackish habitats.

Table 4. Status of Native Animals in Delaware³.

Taxonomic Group	Total Species	Rare	Uncommon	Common	State Extirpated or Historical	Unknown Status	State Endangered	Federal Endangered or Threatened	DEWAP Tier 1	DEWAP Tier 2
Reptiles	34	12	2	16	2	2	2	1	9	10
Amphibians	27	8	3	16	0	0	2	0	2	7
Freshwater Mussels	13	6	0	2	4	1	6	1	7	3
Mammals	45	1	4	25	5	10	1	1	2	8
Birds	314	62	32	93	12	115	24	1	44	91
Fish	66	16	4	44	0	2	1	1	9	9
Insects	399	104	44	110	64	77	9	0	28	179
Total	898	209	89	306	87	207	45	5	101	307

³ Only animals found in terrestrial, freshwater and brackish habitats are included. The total number of species is a conservative estimate given that many more invertebrate species likely occur in the state.

Forest Birds:

In Delaware's forests, avian diversity varies depending on geographic location, forest type, and forest structure. Of the 113 native bird species that are dependent on forest for breeding, migrating, or overwintering, eight are considered state-endangered (Table 5). Distributed widely throughout the State, some avian species depend on forest block size, tree size, plant community composition, forest and understory structure and forest condition and growth stage, further highlighting the importance of maintaining forest diversity and health.

Table 5. State-endangered Forest-dependent Bird Species

Common Name	Scientific Name	State Status	DEWAP Tier	State Rank
Bald Eagle	<i>Haliaeetus leucocephalus</i>	E	1	S2B,S3N
Cooper's Hawk	<i>Accipiter cooperii</i>	E	1	S1B
Red-headed Woodpecker	<i>Melanerpes erythrocephalus</i>	E	1	S1
Brown Creeper	<i>Certhia americana</i>	E	1	S1B,S4N
Northern Parula	<i>Parula americana</i>	E	1	S1B
Cerulean Warbler	<i>Dendroica cerulea</i>	E	1	S1B
Swainson's Warbler	<i>Limnothlypis swainsonii</i>	E	1	SHB
Hooded Warbler	<i>Wilsonia citrina</i>	E	1	S1B

Bald Eagles are more dependent on the overall size of trees, rather than size of the forested area, and are closely tied to forests with associated waterways that support a suitable prey base, particularly fish. In New Castle County and much of Kent County, eagles most often select large deciduous trees for nesting with a strong shift to pines in southern Kent and Sussex Counties. Although Bald Eagles are dependent on mature forest for nesting, they rarely nest within the forest interior. In cases where a nest is not located along the forest edge, eagles tend to select the tallest trees within the interior part of a forest. In contrast, Cooper's Hawks require larger forest blocks for nesting, but will nest in trees of varying size.

Red-headed Woodpeckers may benefit from a variety of forest habitats, but are mostly dependent on the forest structure rather than type. In many cases, Red-headed Woodpeckers require large, partially barkless snags, such as those left behind following sustainable forestry practices. The creation of large, open scrubby areas following a harvest can support Delaware's Red-headed Woodpecker population in addition to adjacent wooded areas that would provide them with adequate foraging habitat. The Brown Creeper, a small brown tree-climbing species also may benefit from sustainable forestry practices. A very rare breeding species in Delaware, it can be common in winter and may be found in a diverse range of forest types and sizes. However, for breeding, this species may benefit from stands of Loblolly or Pitch Pine, nesting behind pieces of loose bark particularly on dead or dying trees.

The last four forest-dependant state-endangered species are warblers, small neotropical migrants that require forest habitat for breeding. Two species, Cerulean Warbler and Northern Parula, both use mature floodplain forest for nesting in Delaware (Northern Parula may also nest in mature upland forest), but these two species differ in nesting heights. The Cerulean Warbler typically nests in semi-open canopy, well above the forest floor and is restricted to the Piedmont region of

Delaware within the northern reaches of the White Clay Creek watershed. In contrast, the Northern Parula may nest at varying heights and throughout the State, but appears to be closely tied to the lichen *Usnea*, commonly called Old Man's Beard. In the Piedmont, this species may nest in evergreens where *Usnea* is not available. *Usnea* is very sensitive to air pollution, thereby restricting its distribution to rural areas or the interior of large forest blocks.

Sharply contrasting with the previous two warbler species, the Swainson's Warbler and the Hooded Warbler nest much closer to the ground. With these two species, the forest structure, particularly the understory, is far more important than the other components of the forest. Hooded Warbler breeding records are widely distributed across Delaware, but are rare. This species requires moist rich upland forest with a very dense understory. Swainson's Warbler also requires a very dense understory, but this species prefers mature forested swamps and bogs and is restricted to Sussex County (Pocomoke and Nanticoke drainages). Although both species are quite rare, there have been no confirmed reports of Swainson's Warbler breeding in Delaware since the 1970's, most likely due to habitat loss and decreased suitability.

Some avian species in Delaware are also considered dependent on the forest interior. These birds require forest habitat away from the forest edge for a variety of reasons. Raptors such as the Red-shouldered Hawk and Broad-winged Hawk are very sensitive to disturbance of any kind. Nesting within the interior of a forest block reduces the potential for disturbance that would otherwise cause these birds to abandon their nesting attempts. Other species, including many forest-dependent songbirds, require forest interior habitat to reduce the predation and parasitism pressure on their respective populations. Associated with forest edge are greater densities of predators such as foxes, raccoons, and even other avian predators such as jays and crows. Parasitism by the Brown-headed Cowbird also occurs more frequently along forest edges where the species can more easily detect host nests.

Several SGCN are considered forest interior-dependent species (Table 6). These species along with other avian taxa dependent on the interior face shrinking forest patches and higher levels of inter- and intra-specific competition for food and nesting resources. Additionally, large forest blocks with adequate interior habitat also benefit non-breeding species that may use these blocks as migratory stop-over sites or for overwintering. Losses of forest-interior habitat may not only affect our local breeding bird populations, but may also place additional stressors on those that spend only a short period in Delaware during spring and fall migration.

TABLE 6. Species of Greatest Conservation Need Dependent on Forest-interior Habitats.

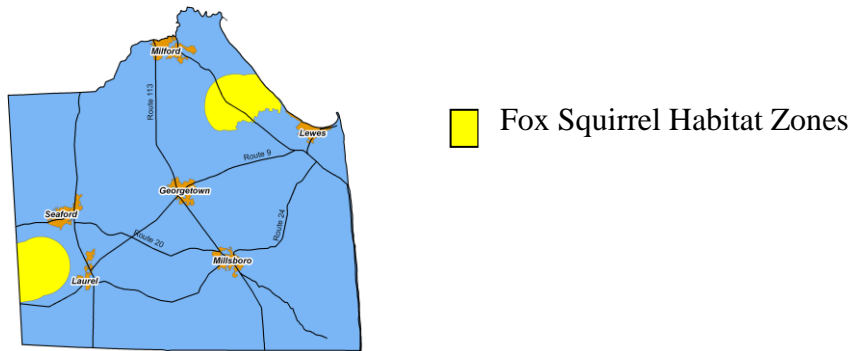
Common Name	Scientific Name	DEWAP Tier
Broad-winged Hawk	<i>Buteo platypterus</i>	1
Brown Creeper	<i>Certhia americana</i>	1
Cerulean Warbler	<i>Dendroica cerulea</i>	1
Wood Thrush	<i>Hylocichla mustelina</i>	1
Swainson's Warbler	<i>Limnothlypis swainsonii</i>	1
Northern Parula	<i>Parula americana</i>	1
American Redstart	<i>Setophaga ruticilla</i>	1
Hooded Warbler	<i>Wilsonia citrina</i>	1
Veery	<i>Catharus fuscescens</i>	2
Black-billed Cuckoo	<i>Coccyzus erythrophthalmus</i>	2
Yellow-throated Warbler	<i>Dendroica dominica</i>	2
Chestnut-sided Warbler	<i>Dendroica pensylvanica</i>	2
Worm-eating Warbler	<i>Helmitheros vermivorus</i>	2
Black-and-white Warbler	<i>Mniotilta varia</i>	2
Great Crested Flycatcher	<i>Myiarchus crinitus</i>	2
Kentucky Warbler	<i>Oporornis formosus</i>	2
Scarlet Tanager	<i>Piranga olivacea</i>	2
Yellow-throated Vireo	<i>Vireo flavifrons</i>	2

Forest-dependent species in Delaware vary in population size and growth. Although we have substantial data for general bird populations during the 1980's, this information is out of date with minor exceptions for specific species. The current Breeding Bird Atlas, to be completed in 2012, will update what is known about all birds in Delaware, including those that are forest-dependent. Following the completion of the Atlas, some species considered rare or in need of conservation attention may have more robust and stable populations than previously thought. However, it is likely that the opposite is also true, in that some species have experienced declines over the past 20 years and require conservation attention to preserve their populations.

Delmarva Fox Squirrel:

The Delmarva fox squirrel (*Sciurus niger cinereus*), is the only terrestrial mammal in Delaware listed as an endangered species. The Delmarva fox squirrel has been reduced to a small portion of its original native range due to habitat loss and hunting. Reintroduction and preservation efforts in Delaware have resulted in some disagreements among landowners and government officials in permissible land uses. The process to develop a Habitat Conservation Plan (HCP) for the squirrel was initiated in 2003, including an HCP advisory team and science team, but has yet to come to fruition. In the meantime, the U.S. Fish and Wildlife Service working with the Delaware Division of Fish and Wildlife reviews all land use activities within a three-mile radius around Delaware's two known fox squirrel populations (Figure 11).

Figure 11. Delmarva Fox Squirrel Habitat Zones



Forest Plants:

Delaware's geography (latitude, proximity to the ocean, north-south orientation) provides the environment for both northern and southern plant species. Delaware is the northern extreme for certain southern species, such as loblolly pine (*Pinus taeda*) and baldcypress (*Taxodium distichum*), while some northern species are not found south of Delaware, except primarily at higher elevations [sugar maple (*Acer saccharum*), basswood (*Tilia americana*), hemlock (*Tsuga canadensis*)]. Delaware's forest interior habitats (both wetland and upland) support the greatest diversity of native vascular plants than any other specific habitat type in the state, with upland forests being the most species-rich forest type. Specifically, 450 taxa (species and varieties) are considered forest interior species in Delaware and 260 of these are considered upland species. None of the tree species known to have occurred in Delaware at the time of European settlement have become extirpated and none of Delaware's tree species are listed on the federal threatened and endangered species list. However, two forest interior plant species are federally listed by the U.S. Fish and Wildlife Service – swamp pink (Threatened, *Helonias bullata*) and small whorled pogonia (Threatened *Isotria medeoloides*). Although Delaware's state endangered species law does not include plants, the Delaware Natural Heritage and Endangered Species Program maintains a list of the state's rare plant species. Approximately 36 percent (163 species) of all native forest interior plants within the state are rare with the greatest number (57 percent) occurring within upland forests. The primary cause of decline is loss of habitat including wetlands and upland forests.

Conclusions: None of Delaware's tree species are federally endangered or threatened; however, significant changes have occurred in Delaware's forest types. In addition to the loss of loblolly pine forests, there is a significant disappearance of baldcypress and Atlantic white-cedar. Additionally, while there are only two federally listed endangered animal and plant species in Delaware – all forest dependent – there are a number of state species of concern that require forest habitat and further loss of forested habitat will place more species at risk. Forest management standards should be structured to protect critical wildlife habitat.

Summary – Criterion 1.

While Delaware has more forested acres than a century ago, forested acres are now declining. Much of this recent loss is due to dramatic population increases in Delaware, which has also produced further forest fragmentation and parcelization. Delaware has taken steps to protect its forestlands – approximately 27 percent (100,000 acres) of its 371,000 acres of forestland are now protected through either public ownership or permanent conservation easements. Nonetheless, substantially more acres must be protected to ensure future generations there is a sufficient forested base to sustain the many services and benefits Delawareans currently enjoy.

Likewise, we must ensure that there is a mixture of forest types. Delaware experienced significant declines in loblolly pine in the late 20th century and a slow but steady increase in the amount of older and larger timber. These trends are not catastrophic but should be addressed to maintain a balance of species composition as well as age and size composition. This balance is necessary to ensure that sufficient habitat is provided for the animal and plant species that require a wide diversity of forest habitat and cover, including threatened species and species of concern. An estimated 37% of forest-dependent plants and animals are species of concern. Maintaining not only a critical mass of forestland but also the wide range of forest types is vital for Delaware and ties directly to two of the State and Private Forestry (S&PF) national themes – *Conserve Working Forestlands* and *Enhance Public Benefits from Trees and Forests*.

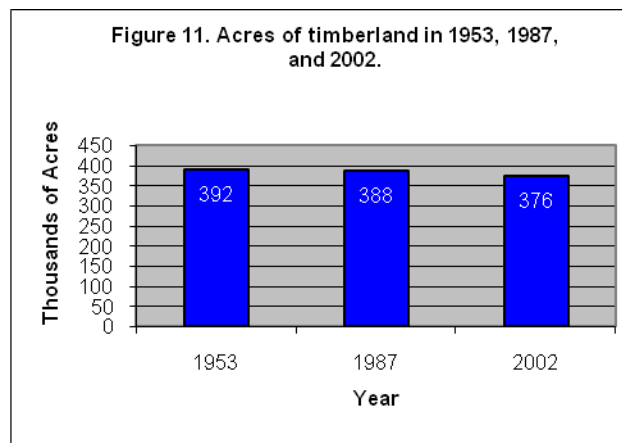
Criterion 2: Maintenance of Productive Capacity of Forest Ecosystems

Importance: Healthy forests provide a wide variety of services and benefits including enhanced water quality, oxygen, wildlife habitat, recreational opportunities, and wood. Forests must be managed sustainably, and all of these benefits must be considered, if we are to continue to enjoy productive forest ecosystems. Tracking not only the amount of forestland available for producing goods and services but also the productivity of that land and the resources harvested is important to ensure their sustainable management. Addressing this criterion directly relates to two of the State and Private Forestry (S&PF) national themes – *Conserve Working Forestlands* and *Enhance Public Benefits from Trees and Forests*.

Indicator 5: Area of timberland.

Introduction: *Timberland is defined as any forestland capable of producing trees which may be profitably and legally harvested. The amount of timberland in the State defines the total forest land base available to produce goods and services for the benefit of society.*

Of the state's 376,000 forested acres in 2002, over 98 percent were classified as timberland. The remaining two percent of the state's forestland is located in areas where regulations prohibit timber harvest or, in very few cases, the soil is not capable of producing a viable timber crop (such as pockets of upland within tidal marshes). Timberland acreage has declined slightly since 1950, as shown in Figure 12.



Renumber to Figure 12

Source: USDA Forest Service Forest Inventory and Analysis.

Conclusions: *Delaware's timberland area has remained constant relative to total forest acreage over the last 50 years. The increase in the rate of development has impacted the forest land base, and as a result, total acreage of timberland has declined slightly.*

Indicator 6: Annual removal of merchantable wood volume compared to net growth.

Introduction: Forests provide valuable products that can be periodically harvested. Forests are also composed of living trees with quantifiable rates of growth. To a large extent, the difference between rate of growth and rate of removal determines whether the resource base is being used in a sustainable manner.

Growth of all species has exceeded removal for more than 40 years. However, removal of softwood growing stock has consistently exceeded growth (Table 7). This fact is partly responsible for the decline of loblolly pine since the mid-twentieth century (see previous discussion within Indicator 2). At the same time, hardwood growth has exceeded hardwood removal of growing stock for every measurement period since 1959, although hardwood removals increased dramatically between 1987 and 1999 – reflecting some new and expanded markets for this resource. Because pine acreage has declined, net softwood growth has been reduced, despite sustainable management of individual pine stands. This trend is a concern and future inventories should closely study the changes in the pine growing stock.

Table 7. Growth and removals of growing stock, millions of cubic feet, 1959-1999.

Year	Softwoods			Hardwoods		
	Growth	Removal	Net	Growth	Removal	Net
1959	6.5	9	-2.5	12.5	4.5	8
1971	4.6	8.1	-3.5	14.6	4.4	10.2
1987	4.1	4.6	-0.5	9.4	4.7	4.7
1999	4.2	6.7	-2.5	12.1	7.7	4.4

Source: USDA Forest Service Forest Inventory and Analysis.

The surplus growth of hardwood species also presents an opportunity. There is growing attention and desire for sustainable, renewable energy sources. Much of Delaware's hardwood growth is concentrated in low-value timber species, such as red maple (now Delaware's most common tree species), sweetgum, and blackgum (black tupelo) (See Figure 2 and Table 7 in Criterion 1 text). While Delaware – or the entire Eastern Shore peninsula – does not contain enough forestland to support a major energy plant, there are sufficient low-value hardwood species to support regional or local systems, such as a heat/energy system for schools or small industry. An example is located in Princess Anne, Maryland, a state prison that utilizes wood chips for heat and electricity. Further analysis of Delaware's forests to better inventory our hardwood resource, including the potential supply for energy, is needed. However, wood energy, on the appropriate scale, is an opportunity to provide renewable, local energy, increase landowners' markets for low quality timber, and improve the species composition of future forests through better forest management.

Conclusions: While overall growth exceeds total removal by timber harvest, important changes in the forest resource have occurred. Softwood removal has exceeded softwood growth for decades, resulting in a decline in the total acreage of loblolly pine, a valuable and fast-growing timber tree. As loblolly pine stands revert to hardwood stands following harvest, hardwood growth has remained high despite increased removals in recent years. These changes suggest the possibility of new and expanded markets for hardwood products as well as the need to stabilize Delaware's softwood resource.

Summary – Criterion 2.

Delaware's timberland area – forestland capable of producing trees which may be profitably and legally harvested – has remained relatively constant over the past century, although timberland acreage is now declining with the recent increase in residential development. Additionally, forest growth continues to exceed removals. However, a concern is that softwood removals, primarily loblolly pine, continue to exceed growth. This lack of sustainability must be addressed to reverse this trend.

Criterion 3: Maintenance of Forest Ecosystem Health and Vitality

Importance: Forests provide a wide variety of services and benefits including enhanced water quality, oxygen, wildlife habitat, recreational opportunities, and wood. Obviously, healthier forests provide a better quality and quantity of these services and benefits. Forest health describes the overall condition of forests and how well they recover from stress. Many factors, both natural and human-induced affect forest health, including: insects, diseases, weather events, development, and the introduction of exotic/invasive species. Combinations of multiple factors presents the greatest challenge. Tracking the various stressors to forest health can help to predict the potential health of future forests and their ecosystems.

Indicator 7: Area of forestland affected by potentially damaging agents.

Introduction: *Damaging agents include insects and diseases that have significant impact on forests as well as wildfires, drought, ice storms, and other natural forces. Damaging agents can alter species composition, reduce growth rates, and disrupt normal forest management activities. While many forces of nature cannot be prevented, it is important to anticipate problems whenever possible, and to develop vigilant early detection programs when new insect and disease threats become apparent.*

Wildfire: Overall, wildfire is not a significant threat to Delaware's forests. Most of Delaware's largest wildfires, in recent history, occur in the marshes along the state's coast. Occasionally, a wildfire within a forest will exceed 100 acres – typically in a loblolly pine plantation – but these are rare and usually in conjunction with a significant drought. Delaware's 60 volunteer fire companies (VFC) are the first responders to wildfires and are very well equipped. Virtually every Delaware VFC has a fully outfitted brush truck with ample wildland firefighting hand tools. The founding of the Delaware Forest Service in 1927 combined with the relatively flat terrain interspersed with ditches, other waterways, roads, and crop fields, along with the volunteer fire companies have greatly reduced the occurrence of wildfires. Since 1998, approximately 240 acres of forestland (less than 1/10 of 1 percent of Delaware's total forestland) have been damaged annually by wildfire (Annual Wildfire Summary Reports and Federal Agency reporting). In 2002, 1,521 acres were damaged, largely as a result of unusually dry conditions and one large fire in central Delaware.

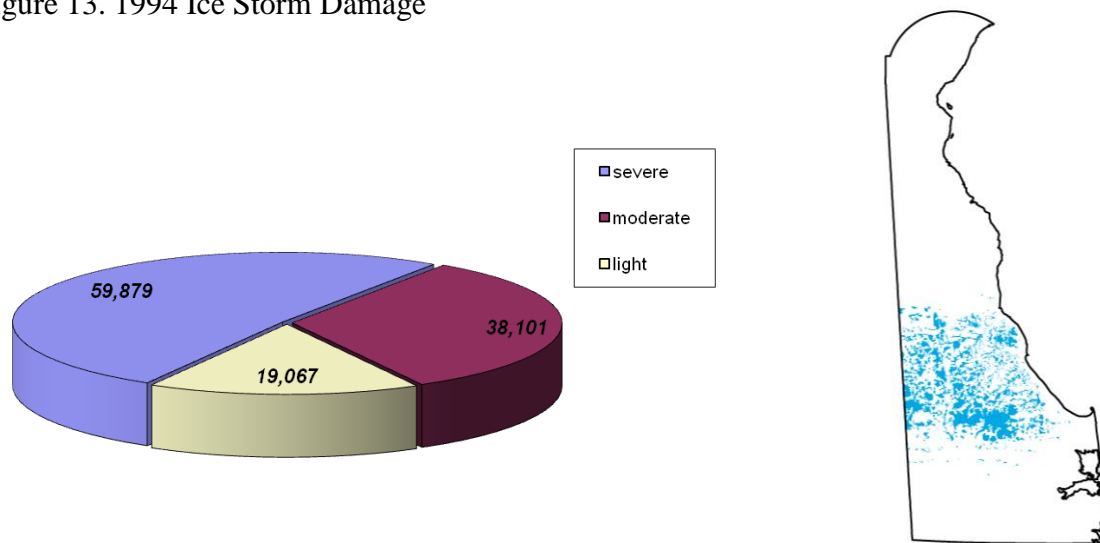
Drought: Since 1895, the earliest year for which data are available, northern Delaware has experienced an average of 1.9 months of drought per year. Southern Delaware has averaged 2.3 months of drought per year. A drought month is defined as a month in which the Palmer Drought Severity Index indicates moderate, severe, or extreme drought conditions (NOAA National Climatic Data Center). Drought can kill trees outright, but is a larger concern as an inducer of stress in trees. Stress predisposes trees to insect and disease problems, which do not normally affect healthy trees.

In 1996, tree mortality resulted in an estimated loss of 4.1 million cubic feet of growing stock. In 2002, this figure was an estimated 7.9 million cubic feet (USDA Forest Inventory and Analysis data) and equals about one percent of all growing stock; this is an acceptable level of mortality in a healthy forest. Every year some trees in any given forest die as a result of competition for light and other resources, as well as events such as wind breakage, lightning, and insects and diseases.

Other Climatic Events (hurricanes, ice storms, etc.): Delaware occasionally is subject to hurricanes although its forests have not experienced significant hurricane damage since Hurricane Hazel in 1954. Delaware typically is impacted by a tropical storm every two to three years but these events do not cause substantial damage.

However, much of Delaware's forests were significantly impacted by an ice storm in February 1994. Approximately 1/3 of Delaware's forests (117,000 acres) were affected by the storm – largely in the central portion of the state.

Figure 13. 1994 Ice Storm Damage



Source: Delaware Department of Agriculture Forest Service

While 15 years have passed since this event, its effect on forest health continues. The trees in the severely and even moderately damaged areas incurred significant damage from breakage and twisting, and consequently their long term health was degraded and they are more susceptible to secondary stressors, namely insects and disease.

Climate Change/Sea-level Rise: There is growing concern about the potential impacts of climate change, including sea-level rise, in Delaware. Delaware's entire eastern border (and its longest border) is the Atlantic Ocean and Delaware River and Bay and 95 percent of the state lies within the Coastal Plain. While there is considerable research needed, several potential issues relating to forests and habitat could include:

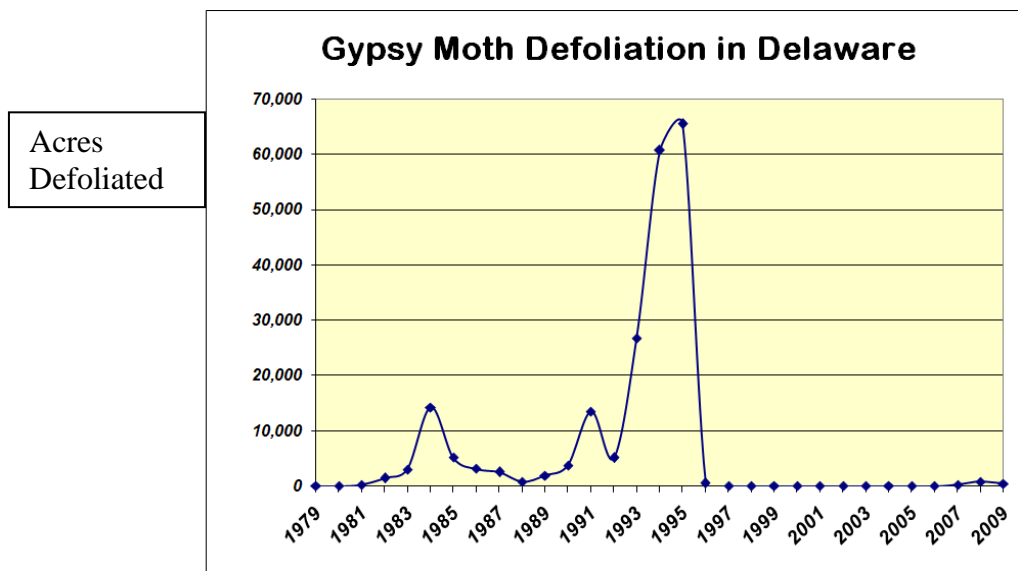
- Migration of maritime forests/riparian areas inland
- Shifts in species range (migration)
- Changes in species composition and/or disappearance of species
- Increases in invasive/nuisance species and disease

Additionally, there is need to establish baseline risk assessment for species and habitats and to consider methods to move low-lying riparian forest buffers inland with any rise in sea level to ensure that these buffers are not lost. It is important that assessments account for possible changes in the future.

Forest Pests:

Several native and exotic pests have historically affected Delaware's rural and urban forests. The southern pine beetle, a native insect, periodically causes localized mortality in stands of loblolly pine. The American chestnut, a stately tree once common in Delaware's woods, has been virtually eliminated by the chestnut blight fungus which appeared in the early 1900s. Another exotic fungus causes Dutch elm disease, which has killed many of the American elms that once graced the towns and cities of Delaware. The gypsy moth, a European species, periodically causes considerable damage to oak forests through defoliation. It was first detected in Delaware in 1979 and its population peaked in the mid-1990s with over 60,000 acres defoliated in 1994 and 1995. The gypsy moth population has decreased dramatically since 1995 with the arrival of the fungus *Entomophaga maimaiga*. From 1997 through 2006, no significant defoliation was found in Delaware. Since 2006, approximately 500 acres have been defoliated each year by the gypsy moth – primarily in the Cypress Swamp.

Figure 14. Gypsy Moth Defoliation in Delaware (1979-2009).



Source: Delaware Department of Agriculture Plant Industries Section

There are four new pests that could seriously impact Delaware's forests – both rural and urban – in the near future; three have not yet been detected in Delaware – Sirex woodwasp (*Sirex noctilio*), Asian longhorned beetle (*Anoplophora glabripennis*), emerald ash borer (*Agrilus planipennis*), and Sudden Oak Death (*Phytophthora ramorum*).

The Asian longhorned beetle (ALB) has been found in New Jersey, New York, and Massachusetts. ALB feeds on many species, but appears to prefer maples. Red maple is the most abundant tree species in Delaware. Forest Service staff have carried out visual surveys for this pest in areas most likely to see its introduction, notably the Port of Wilmington. No reliable trap survey has yet been developed for this pest.

Emerald ash borer (EAB) feeds exclusively on ash, and infestations are present within 100 miles of Delaware's borders in both Maryland and Pennsylvania. While ash represents only one percent of

our rural forest, it has been planted widely in urban areas and some communities have nearly a 100 percent ash component. DDA staff have completed visual surveys as well as trapping programs throughout Delaware since 2007. In 2010, a novel “bio-surveillance” approach will be used. Colonies of native wasps that prey exclusively on members of the EAB genus will be monitored to determine whether EAB is present in the area.

Sirex noctilio (Sirex) has been detected in northern Pennsylvania and New York, where it has caused considerable damage in red pine stands. Loblolly pine, a mainstay of Delaware’s forest industry, has never been infested in its natural setting. However, the potential for severe loss is present, so the Delaware Forest Service has engaged in trap surveys for this pest since 2006. Surveys have involved traps baited with a special “*Sirex noctilio* blend” formulation, as well as trap trees deliberately stressed to attract Sirex if it is in the area.

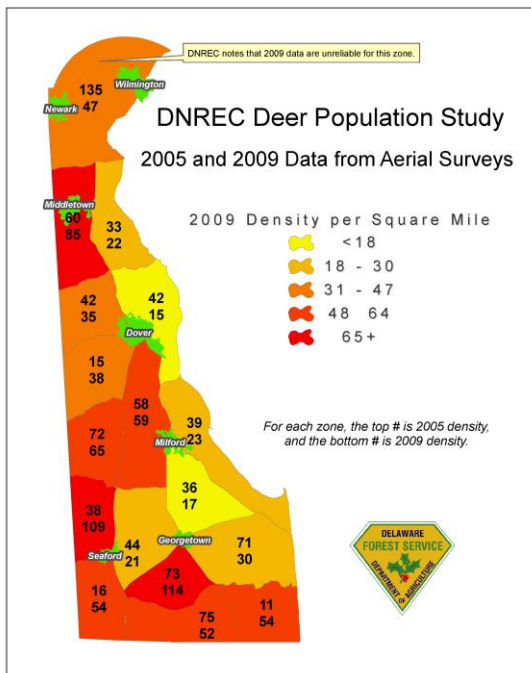
Sudden Oak Death (SOD) threatens Delaware’s oaks, prized for both wildlife and commercial value. SOD has caused widespread destruction of tanoak and other species on the west coast. Landscaping plants later determined to have been infected with the spores of this pathogen have been shipped from western nurseries to the mid-Atlantic region. Not all of these infected plants could be accounted for, so surveys for the causal agent of SOD were carried out from 2004 through 2008. Surveys included sampling of potential host material in forests adjacent to nurseries, as well as a stream survey technique designed to sample the entire contributing watershed.

None of these pests has been detected as a result of these surveys. Survey efforts will continue in the future, and as new threats emerge, forest health staff will continue to respond with appropriate surveys and outreach efforts.

Bacterial Leaf Scorch (*Xylella fastidiosa*), unlike the previous four pests, is believed to be a native pathogen. The reason for its apparent surge in recent years in the mid-Atlantic region has yet to be explained adequately. Spread from plant to plant by insects, bacterial leaf scorch (BLS) interferes with normal water movement through trees and leads to dieback and eventual mortality. The primary hosts of BLS in Delaware are northern red, pin, scarlet, and black oaks. Pin oak is widely planted in urban areas throughout the state while northern red and black oaks are found in many rural forests. Surveys in 2006 and 2007 found that BLS is common in both urban and non-urban forests throughout the State. In recent years Delaware has taken a very proactive stance in studying this disease in the non-urban forest setting. An ongoing effort involving 89 trees at Blackbird State Forest in southern New Castle County could help answer some of the difficult questions associated with this disease, including rate of decline and economic cost. There are no proven techniques to treat or prevent BLS.

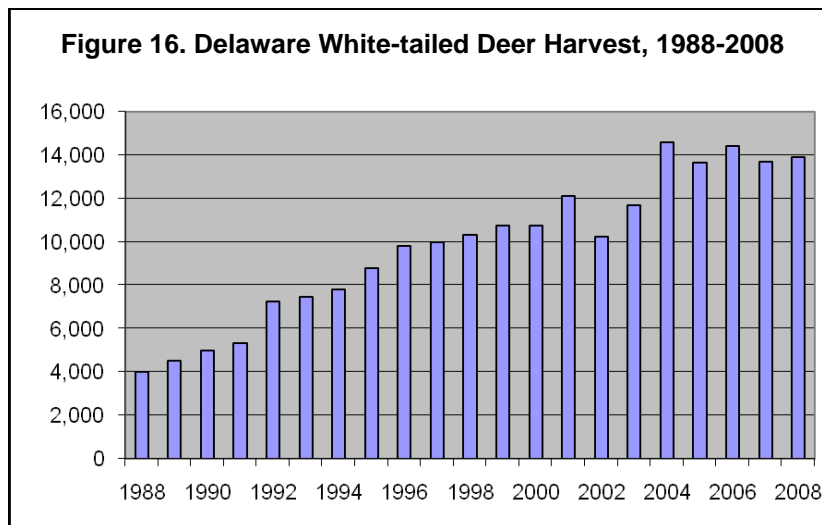
White-tailed deer (*Odocoileus virginiana*) enjoy near-ideal habitat throughout Delaware. As a result, in some portions of the state, deer populations have reached densities of 200 per square mile. Below are deer population estimates for 2005 and 2009 based on aerial surveys for regions throughout Delaware (Figure 15).

Figure 15. Delaware Deer Population Estimate, 2005 and 2009.



Source: Delaware Department of Natural Resources and Environmental Control, Division of Fish and Wildlife.

In recent years, hunting regulations have been changed to allow more deer to be killed and to encourage the harvest of does, which is the most efficient means of reducing deer densities. The annual deer harvest has tripled since 1990 (Figure 16) and the Quality Deer Management Association (QDMA) reported in *Deer Harvest Trends – 2008* that Delaware had the highest percentage of antlerless deer harvest in 2005 (70 percent) among the lower 48 states, but populations remain high.



Source: Delaware Department of Natural Resources and Environmental Control, Division of Fish and Wildlife.

High deer densities can result in browse damage to understory plants in the forest. Studies in other states have shown that populations of more than 20 to 25 deer per square mile can impair seedling

growth and negatively influence species composition in a developing stand. Understory nesting habitat for some birds, particularly neotropical migratory species, can also be reduced dramatically. A deer exclosure study has been initiated by the DFS to quantify the browse effect in Delaware's hardwood forests. The study will monitor understory vegetation at fenced sites, and at control plots without fencing, over a 10-year period.

Invasive Plants:

Non-native, invasive plants are often un-noticed in many forests; however, their presence continues to grow and impact Delaware's forests, particularly in fragmented forests, such as in urban areas and along the edge of expanding urban/suburban areas. While there is not an estimate of the amount of native plants displaced by these invasives, the Delaware Natural Heritage Program has identified 46 species of non-native, invasive plants that are detrimental to forest interior habitat. Table 8 contains the list. Many of these species are found in Delaware's forests and/or are out-competing native trees in urban forests and/or open areas reverting back to forestland.

Table 8. Delaware's Invasive Plants

<i>Acer platanoides</i>	Norway maple
<i>Ailanthus altissima</i>	tree-of-Heaven
<i>Akebia quinata</i>	five-leaf akebia
<i>Alliaria petiolata</i>	garlic mustard
<i>Ampelopsis brevipedunculata</i>	porcelain-berry
<i>Aralia elata</i>	Japanese angelica-tree
<i>Berberis thunbergii</i>	Japanese barberry
<i>Bromus inermis</i>	awnless brome
<i>Celastrus orbiculatus</i>	Oriental bittersweet
<i>Clematis terniflora</i>	Japanese virgin's-bower
<i>Elaeagnus umbellata</i>	autumn olive
<i>Euonymus alatus</i>	winged euonymus
<i>Euonymus fortunei</i>	winter creeper
<i>Ficaria verna (Ranunculus ficaria)</i>	lesser celandine
<i>Galanthus nivalis</i>	snowdrops
<i>Gleditsia triacanthos</i>	honey-locust
<i>Hedera helix</i>	English ivy
<i>Hemerocallis fulva</i>	orange daylily
<i>Humulus japonicus</i>	Japanese hops
<i>Leucjum aestivum</i>	summer snowflake
<i>Ligustrum obtusifolium</i>	border privet
<i>Ligustrum sinense</i>	Chinese privet
<i>Ligustrum vulgare</i>	European privet
<i>Lonicera japonica</i>	Japanese honeysuckle
<i>Lonicera maackii</i>	Amur honeysuckle
<i>Lonicera morrowii</i>	Morrow's honeysuckle
<i>Lysimachia nummularia</i>	creeping loosestrife
<i>Magnolia kobus</i>	Kobus magnolia
<i>Microstegium vimineum</i>	Japanese stilt grass
<i>Pachysandra terminalis</i>	pachysandra

<i>Persicaria longiseta</i> (<i>Polygonum cespitosum</i>)	longbristle smartweed
<i>Persicaria perfoliata</i> (<i>Polygonum perfoliatum</i>)	mile-a-minute
<i>Phyllostachys aurea</i>	bamboo
<i>Pinus thunbergiana</i>	Japanese black pine
<i>Reynoutria japonica</i> (<i>Polygonum cuspidatum</i>)	Japanese knotweed
<i>Rhodotypos scandens</i>	jetbead
<i>Rosa multiflora</i>	multiflora rose
<i>Rubus phoenicolasius</i>	wineberry
<i>Rubus triphyllus</i>	three-leaf blackberry
<i>Urtica dioica</i>	stinging nettle
<i>Viburnum dilatatum</i>	exotic arrow-wood
<i>Viburnum setigerum</i>	tea viburnum
<i>Vinca minor</i>	lesser periwinkle
<i>Wisteria floribunda</i>	Japanese wisteria
<i>Wisteria sinensis</i>	Chinese wisteria

Source: Delaware Natural Heritage Program.

Summary – Criterion 3

Delaware’s forests face a variety of forest health concerns – including ones that are present and ones that could potentially arrive in the near future. Weather events, such as the 1994 ice storm, pose sporadic threats to forest health and can significantly impact the long-term health of our forests. Neither the normal “background” mortality rate nor the occurrence of wildfires present a major threat to Delaware’s forest resources. Constant browse damage to seedlings by a large deer herd has likely begun to alter species composition in hardwood forests throughout the State. Non-native, invasive plants are also beginning to significantly impact Delaware’s forests – particularly in the northern portion and within urban/suburban areas. Several exotic insects and diseases also present potential threats to rural and urban forests; therefore, surveys to assess current threats and to detect new pests will continue to be vital to forest health. Addressing all of these concerns is important to ensure that Delaware maintains healthy forest ecosystems. Thankfully, none of these threats are currently a forest health catastrophe; however, each has the potential to produce substantial impact, and in combination over time, could be devastating. Taking steps to minimize their threat and developing plans to respond to their future occurrences is vital and ties directly to one of the State and Private Forestry (S&PF) national themes – *Protect Forests from Harm*.

Criterion 4: Conservation and Maintenance of Soil and Water Resources

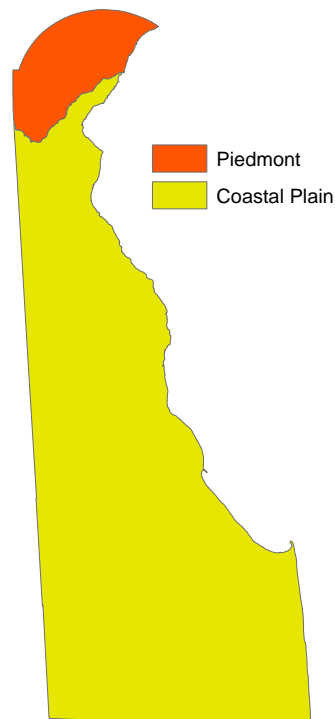
Importance: Soil and water are the foundation for all other forest resources. Forests protect soil and water quality by reducing sedimentation and erosion. Typically, watersheds with higher proportions of forestland have better water quality and quantity. Riparian (forested) buffers and forested wetlands can filter sediment and other pollutants from adjacent land uses before they reach waterways. Tracking watershed forests and the soil and water quality within forests can help to gauge a region's water quality. Conserving and maintaining soil and water resources is directly related to the State and Private Forestry Redesign national theme *Enhance Public Benefits from Trees* as it protects and enhances water quality and quantity.

Indicator 8: Soil quality on forestland.

Introduction: Plants require soil to grow. Soil quality influences the type of vegetation that will grow at a particular site, as well as the rate of growth of that vegetation. Soils are generally of adequate quality in Delaware to support forest growth; the native vegetation on all but the wettest sites was forest. Today, soil drainage is one of the primary factors determining forest cover type, growth rate, and operational limitations.

Most of Delaware's forests occur on three broad soil types, (1) Piedmont soils, (2) Coastal Plain well-drained soils, and (3) Coastal Plain poorly drained soils. While all types are capable of producing good growth, native cover types and equipment limitations differ.

Figure 17. The physiographic provinces of Delaware.



The Piedmont physiographic province accounts for about five percent of the land area of Delaware. It is roughly delineated as the portion of the state lying north of Interstate 95. Piedmont

soils tend to have a clay component and may be well drained or poorly drained, depending on topography and specific soil properties. Native cover is a hardwood mix containing red and white oaks, beech, hickory, and yellow-poplar.

The Coastal Plain physiographic province accounts for the southern 95 percent of Delaware. Topography is generally flat and low lying and most of these soils have a large sand component.

Well-drained soils on the Coastal Plain benefit from at least minimal elevation above low lying areas. The native cover type on these soils is mixed hardwoods and, in the southern part of the state, loblolly pine. A standard measure of wood volume is the board foot, which is defined as a 12-inch by 12-inch board that is one inch thick. Loblolly pine stands on well drained Coastal Plain soils typically yield 11,500 board feet per acre at age 50 according to USDA NRCS Soil Survey publications.

The other predominant Coastal Plain soil type occurs in areas with poor drainage and/or a high water table. Native forest cover usually includes red maple, blackgum, holly, sweetgum, and water-tolerant oaks, with some loblolly pine in the southern half of Delaware. While loblolly pine stands on these soils may yield over 16,000 board feet per acre at age 50, seasonal wetness often restricts access for timber harvest.

Soil quality is relatively good throughout Delaware. While nearly all of Delaware's land was farmed at one time since European settlement – except the very wettest sites – these activities resulted in minimal damage. Unlike other areas of the country that experienced significant soil erosion the clearing of forests for agriculture, Delaware's relatively flat terrain did not produce such dramatic erosion.

The primary influence of man on soils is the extensive network of man-made ditches that were dug in the Coastal Plain areas, particularly in the latter half of the 20th century. Many streams were straightened and/or channelized and an extensive network of connected ditches was completed in the headwaters of many watersheds to improve drainage for agricultural use. These ditches are usually referred to as tax ditches because landowners are taxed for the installation and maintenance of the ditch system. There are approximately 2,070 miles of tax ditches in Delaware that drain around 360,000 acres. This increased drainage often resulted in not only the conversion of forestland to agriculture but also a change in forest type. For instance, the occurrence of species that require very wet or saturated soils, such as baldcypress and Atlantic white-cedar, was reduced as their habitat was altered. There are opportunities on some tax ditch systems to alter their drainage so as to re-establish the original hydrology within forested areas.

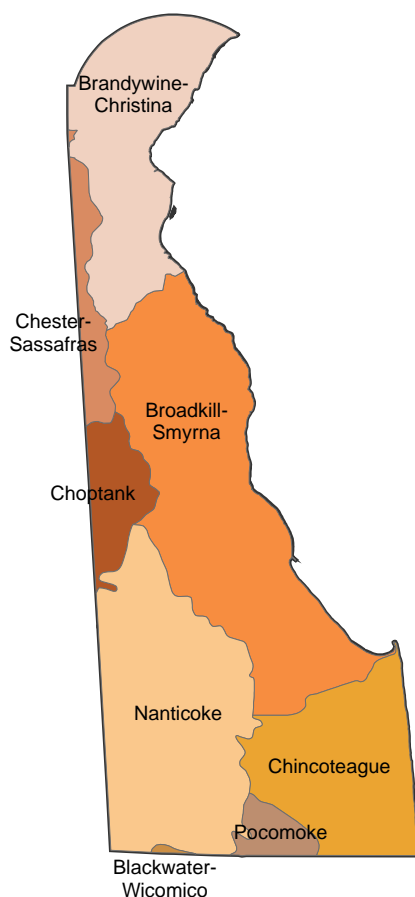
Conclusions: Most of Delaware is located within the Coastal Plain although approximately five percent of Delaware is considered Piedmont. Forest soils are generally productive for tree growth throughout Delaware. The primary impact of man upon Delaware's soils is the extensive ditch system installed in the latter half of the 20th century. This not only resulted in the clearing of larger areas of forests but also produced different forest types in some cases through changes in the hydrology. With minimal changes in elevation, equipment limitations on wetter soils represent the only major soil-related operational constraint on forest management activities.

Indicator 9: Area of forest land adjacent to surface water and forest land by watershed.

***Introduction:** Forested areas are important to water quality. Within forests, rainwater percolates into the ground and recharges the aquifers that provide us with drinking water. Forests typically do not act as sources of pollutants, so, other things being equal, watersheds with more forest cover tend to have cleaner water. Along streams, forest cover provides shade to regulate water temperature and roots reduce soil erosion. Trees absorb nitrogen and phosphorous, which in high amounts can cause water pollution. Forested buffers along waterways also increase the distance between sources of pollution and the waters they could pollute.*

The United States Geological Survey utilizes an 8-digit Hydrologic Unit Code (HUC) to identify major watersheds. Under this system, Delaware contains all or part of eight HUC watersheds (Figure 18).

Figure 18. Major Watersheds of Delaware.



Source: United States Geological Survey.

Approximately 35 percent of Delaware is located within the Chesapeake Bay watershed. The Chesapeake has been recognized for decades as one of the most important estuaries within the United States and numerous efforts are underway to improve its water quality. These efforts were recently highlighted by White House Executive Order 13508: Chesapeake Bay Protection and Restoration (May 12, 2009). Delaware is also a Headwater State Partner within the Chesapeake Bay Program, a unique regional watershed partnership working to improve the Bay's water quality.

since 1983. The remaining areas of the state drain to the Delaware River and Bay and Atlantic Coast.

Overall, Delaware is about 30 percent forested. Forest cover varies by watershed from a low of 21 percent to a high of 58% (Table 9). The Pocomoke, Nanticoke, and Choptank watersheds in the southwestern portion of the state contain the highest proportion of forest.

Table 9. Forestland by Watershed.

Watershed	Forest Acres	Total Acres	% Forest
Pocomoke	15,455	27,294	57%
Chincoteague	56,852	175,140	32%
Blackwater-Wicomico	363	1,646	22%
Nanticoke	121,473	313,346	39%
Broadkill-Smyrna	90,482	404,728	22%
Choptank	25,377	61,125	42%
Chester-Sassafras	16,765	47,031	36%
Brandywine-Christina	44,432	219,690	20%

Source: Delaware Department of Agriculture Forest Service

Geographic Information System (GIS) technology allows sophisticated analyses of geographic data on standard desktop computers. A GIS proximity study was carried out to identify all forestland in the state that lies within 100 feet of surface waters. These “buffer” areas are important for water quality because they can trap sediment and other pollutants before they reach streams. Buffer areas also serve as wildlife corridors and provide aesthetic benefits in many cases.

In all, approximately 34,800 acres of forest are acting as buffers using the 100-foot criterion. This acreage represents about nine percent of Delaware’s forestland.

Delaware has approximately 3,100 miles of rivers and streams. About 40 percent of these stream miles are currently buffered by at least 100 feet of forest on both sides. The other 60 percent do not benefit from forest buffers and are located primarily in agricultural and urban areas where pollution may be occurring at higher rates.

Conclusions: The percentage of forest cover varies significantly by watershed, with the densest cover in the southwest quadrant of the state; however, only one of Delaware’s watersheds is over 50 percent forested. Roughly one-tenth of the forestland in Delaware is in riparian buffers, so forest management activities should be tailored to reduce sedimentation of waterways. Because more than half of Delaware’s stream miles do not have riparian buffers, opportunities are available to establish buffers on agricultural lands and in urban areas to protect and improve water quality.

Indicator 10: Water quality in forested areas.

***Introduction:** Clean and abundant water is necessary for all species. Clean water is also important for fishing, swimming, and other forms of recreation. Forests play an important role in protecting and improving water quality – both surface and groundwater. Forested wetlands serve as sinks to slow runoff, filter water, and release clean water into waterways and underground aquifers. The use of Best Management Practices (BMPs) when harvesting timber helps maintain water quality in forested areas.*

Surface Water:

Delaware faces considerable water quality challenges. The Environmental Protection Agency (EPA) publishes a list of water bodies in each state that fail to meet water quality standards. Most of the streams and lakes in Delaware are listed as impaired by the EPA. In 2008, the Delaware Department of Natural Resources and Environmental Control (DNREC) found that 88 percent of Delaware's rivers and streams did not fully support swimming use and 97 percent did not support fish and wildlife use. Additionally, DNREC found that 44 percent of Delaware's fresh water ponds and lakes did not fully support swimming use and 89 percent did not fully support fish and wildlife use. The cause of impairment in most cases is an excess of nitrogen and phosphorus. These nutrients cause excessive algal growth, which in turn leads to algal blooms and oxygen-starved water conditions that can kill fish. Nitrates are also a known carcinogen. Nitrogen and phosphorus pollution comes from many sources, including fertilizer applied by farmers and homeowners, domestic and wild animals, and septic systems.

To meet the EPA's requirements, Delaware must develop plans to reduce pollution to acceptable levels. The Total Maximum Daily Load (TMDL) approach, required by EPA, quantifies current levels of each pollutant as well as the maximum allowable level. Teams are assembled on a watershed-by-watershed basis to develop strategies to reduce pollution to TMDL levels. These strategies are known as "Pollution Control Strategies" and can incorporate new regulations, education, and specific clean-up efforts.

The multiple programs addressing the nutrient problem generally credit forests as the most beneficial land use in terms of nitrogen and phosphorus pollution rates. Creating forestland (e.g., afforestation) from a different type of land use reduces the amounts of nitrogen and phosphorus that reach streams and groundwater. These reductions are incorporated into the model used to demonstrate that pollution is being reduced to acceptable levels. Delaware participates in the Conservation Reserve Enhancement Program (CREP) that provides cost shares and annual rental payments to landowners who plant trees to improve water quality. Over 3,600 acres of cropland were planted with trees as well as 126 acres of riparian forests. More information about CREP is included in the discussion of Indicator 14. Targeted planting of trees in urban areas around catch basins and along drainage areas can also reduce the velocity and impact of stormwater runoff.

When trees are harvested for commercial use, operators must obtain a permit from the DFS. Forest Service personnel ensure that Best Management Practices (BMPs) are used to prevent unnecessary pollution of waterways by sediment and other pollutants. Timber harvest BMPs are discussed in more detail under Indicator 17, "Forest Management Standards/Guidelines."

While most of Delaware's drinking water is supplied through groundwater, there are two cities – Newark and Wilmington – that rely on surface water for a portion of their drinking water supply. The Hoopes Reservoir holds 2 billion gallons of water and provides a reserve supply for the City

of Wilmington when the water level of the Brandywine River becomes too low. Water is pumped into the reservoir from the Brandywine River when necessary and when water levels permit. Water also enters the Hoopes from a relatively small watershed – approximately 1,250 acres of which approximately 486 are forested. The Newark reservoir contains approximately 318 million gallons and is supplied by pumping water from the nearby White Clay Creek. Maintaining as much forestland as possible within the Brandywine and White Clay Creek watersheds (both of which extend well into Pennsylvania) as well as the small watershed that directly feeds the Hoopes Reservoir is vital to water quality.

Groundwater:

Forests also play a critical role in Delaware's groundwater recharge. Delaware's Division of Water Resources has identified approximately 119,000 acres of excellent groundwater recharge area – approximately ten percent of Delaware's land base. For Delaware, groundwater recharge potential maps show land areas characterized by their abilities to transmit water from land surface to a depth of 20 feet. Excellent recharge areas allow precipitation to rapidly infiltrate to the underlying aquifer and are typically areas with natural vegetative cover, flat topography, permeable soils, a deep water table, and the absence of confining beds. These areas provide much of the groundwater to recharge Delaware's underground aquifers – the state's primary water supply for all purposes (drinking water, irrigation, etc.). Of the 119,000 acres, almost ¼ are forested (28,250 acres). Keeping these areas forested will not only help maintain Delaware's groundwater supply but also help filter and clean this water.

Forested Wetlands:

Wetlands provide a wide range of valuable functions, including slowing water runoff, trapping sedimentation and filtering pollutants before they reach streams and other waterways, valuable habitat for many species of wildlife and plants, and recreational opportunities. Forested wetlands are widely recognized as the premier wetland type. Delaware has lost a significant portion of its forested wetlands through drainage and clearing for other land uses. Additional wetlands have been degraded by a variety of impacts including invasive species, fragmentation, improper timber harvests, sediment and chemical runoff from adjoining land uses, and drainage. Forested wetland losses have slowed dramatically in recent decades with new laws, regulations, and a greater public awareness and appreciation of the importance of wetlands. The most recent estimates of forest wetlands, based on an analysis of 1992 land cover by the Delaware Department of Natural Resources (known as the State Wetland Mapping Project – SWMP) found the following:

Table 10: Palustrine Forested Wetlands

<u>County</u>	<u>Acres</u>	<u>% of Forested Wetlands in DE</u>
New Castle	12,905	9
Kent	55,565	38
Sussex	78,951	53
TOTAL	147,421	

As discussed in Criterion 1, Coastal Plain seasonal ponds are a very important component of forested wetlands. In addition to the habitat function they serve for salamanders and other biota, forests help maintain the water quality of seasonal ponds by filtering nutrients and other pollutants, preventing invasive species from readily establishing in the ponds, and also serving as groundwater recharge areas. Rainwater slowly percolates through forest soils, and over time, this groundwater flows into seasonal ponds flooding them in the winter and spring.

As mentioned previously, clean and abundant water is a byproduct of forests; therefore, it is important that forest management activities protect water quality. The DFS participates in a regional BMP monitoring program to quantify the success of timber harvest BMPs. Data is collected at harvest sites to determine rate of soil erosion and other measurable factors. Delaware and several other states field tested the BMP monitoring program.

Conclusions: Delaware faces important water quality challenges with over 88 percent of our watersheds classified as impaired by the EPA. Protecting and maintaining excellent groundwater recharge areas is vital to the state's primary water resource. Additionally, while surface water is not a primary source of drinking water in Delaware, it is a source for two of Delaware's largest cities. Forests play, and will continue to play, an important role in helping to protect and enhance water quality and quantity. Conserving forests that are critical to water quality and quantity, such as forested wetlands and riparian forests, is vital to Delaware's environment and economy.

Summary – Criterion 4

Forests play a vital role in conserving and enhancing soil and water quality and quantity. While nearly all of Delaware's watersheds are under 50 percent forested and most of Delaware is located in the Coastal Plain with little topography, our forests nonetheless provide excellent buffers and protect groundwater recharge areas. Forests also help to protect water quality for Delaware's two cities that utilize surface water for drinking water supplies. Approximately one-third of Delaware is located within the Chesapeake Bay watershed and protecting and expanding forested areas and buffers in this area as well as throughout all of Delaware is important. There could also be opportunities to restore the hydrology of bottomland forests by working with Delaware's tax ditch system. Regardless, maintaining and expanding forest buffers and forested areas critical to water quality protection is directly related to one of the State and Private Forestry (S&PF) national themes – *Enhancing Public Benefits from Trees and Forests*.

Criterion 5: Maintenance of Forest Contribution to Global Carbon Cycles.

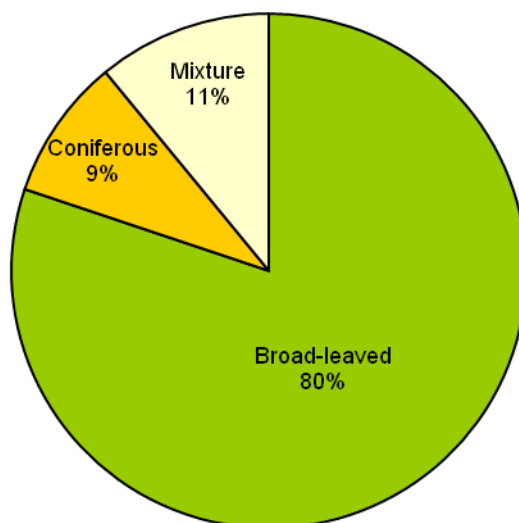
Importance: There is growing evidence that increased levels of carbon-containing gases in the atmosphere is a major source of climate change. These “greenhouse” gases are believed to contribute to the warming of the earth’s atmosphere. Many scientists now advocate reducing the amount of carbon in the atmosphere to mitigate this warming effect. Healthy, growing trees store carbon both above ground (limbs, boles, etc.) and below ground (roots) through the process called carbon sequestration. Both rural and urban forests play a large role in carbon sequestration and urban forests around buildings also help reduce energy consumption by moderating temperatures by providing shade and windbreaks.

Indicator 11: Forest ecosystem biomass and forest carbon pools.

Introduction: Trees store carbon (referred to as a carbon sink) in their xylem (wood) and other tissues. Carbon storage is important because carbon (in the form of carbon dioxide) is believed to contribute to global warming via the “greenhouse effect.” Carbon dioxide concentrations in the atmosphere have been rising every year since the industrial revolution. Forests “lock up” some of the carbon emissions produced each year and reduce the rate of increase of atmospheric carbon dioxide. Forest inventory data can be used to quantify carbon storage in Delaware’s forests.

Data from the 1999 growing season place the above ground live tree carbon storage in Delaware’s forests at 12.6 million U.S. tons. Four-fifths of the above ground carbon is found in broadleaved stands (Figure 19).

Figure 19. Aboveground Live-tree Carbon by Forest Type



Source: USDA Forest Service Forest Inventory and Analysis.

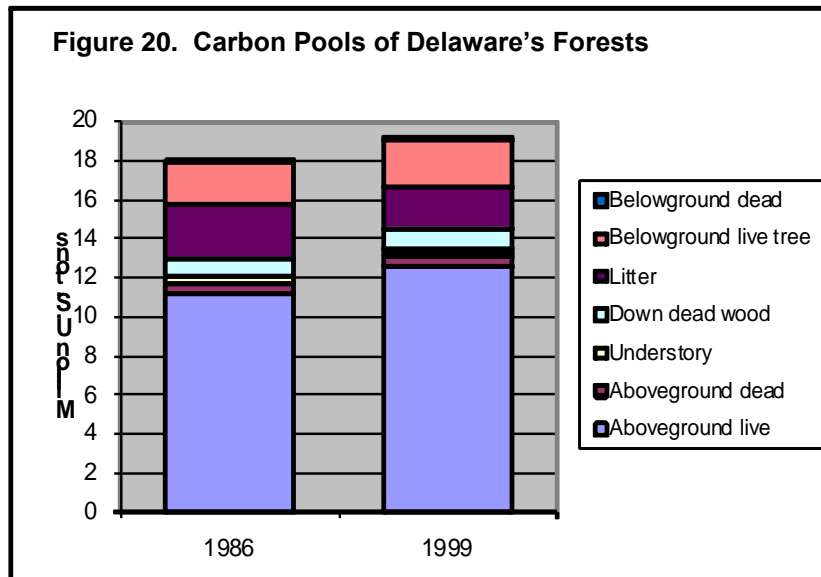
Dead, understory, litter, and below ground components account for an additional 6.6 million U.S. tons, for a total forest carbon pool of 19.2 million tons in 1999. A detailed breakdown of the carbon pool in Delaware's forests is located in Table 11.

Table 11. Total forest carbon pool by forest component, 1999.

Component	U.S. Tons (Millions)
Aboveground live tree	12.6
Aboveground standing dead	0.6
Understory	0.4
Down dead wood	1.0
Litter	2.1
Belowground live roots	2.4
Belowground dead roots	0.1
Total	19.2

Source: USDA Forest Service Forest Inventory and Analysis.

Figure 20 shows the change in carbon storage for the period 1986-1999. Total carbon storage increased by seven percent from 18.0 to 19.2 million tons. This increase is expected because the trees in Delaware's forests are growing larger and therefore can store more carbon. While this trend of increasing carbon storage is desirable, it is important to remember that as forests continue to age their ability to sequester additional carbon decreases and eventually ceases. Therefore, maintaining a balanced mixture of young to mature forests is important not only for wildlife habitat, forest management, and other purposes, but also for carbon sequestration.



Source: USDA Forest Service Forest Inventory and Analysis.

Urban forests also store and sequester significant amounts of carbon. Results from a study of urban forests – *Urban and Community Forests of the Southern Mid-Atlantic Region* (Nowak and Greenfield 2009) – estimated the following services for urban forests in Delaware. More localized data are needed for more precise estimates, but these values reveal first-order approximations.

- 1.3 million metric tons of carbon stored (\$29.6 million value)
- 44,000 metric tons/year of carbon sequestered (\$1.0 million value)

Additionally, Nowak and Greenfield also estimated other pollutants removed by Delaware's estimated 7.1 trees in urban and community forests:

- 1,710 metric tons/year total pollution removal (\$13.5 million value), specifically:
 - 29 metric tons/year of CO removed (\$40,200 value)
 - 242 metric tons/year NO₂ removed (\$2.4 million value)
 - 744 metric tons/year of O₃ removed (\$7.4 million value)
 - 221 metric tons/year of SO₂ removed (\$536,000 value)
 - 476 metric tons/year of PM₁₀ (particulate matter) removed (\$3.1 million value)

Forests also help lower energy costs, thus reducing energy consumption and, indirectly, lowering carbon emissions. In *Urban Forest Assessment in Northern Delaware* Nowak, et al. (2008) estimated that urban trees in New Castle County save approximately \$403,000 annually in residential building energy costs, including \$183,000 within the City of Wilmington.

Delaware's forests are excellent carbon sinks. Furthermore, research has shown that forest management activities can increase the amount of carbon stored by forests. Preserving forests during development is also important for carbon storage because these forests are usually not replaced or, at best, only partially replaced so this carbon storage source is eliminated or greatly reduced. There is an emerging market for carbon; many European countries now have a regulated carbon cap and trade system. Voluntary carbon markets are growing within the United States and Delaware is a member of the Regional Greenhouse Gas Initiative (RGGI), which includes ten Northeastern and Mid-Atlantic states that have agreed to lower their carbon emissions from the power sector by 10 percent by the year 2018. Currently, the only forestry practice approved by RGGI for carbon credit is afforestation (planting open land with trees); however, forest management, urban forestry, and avoided deforestation could provide additional income opportunities for landowners while sequestering carbon. Conserving our existing forests, expanding forestland where possible – including urban forest areas and community open spaces, and including carbon storage in forest management plans will help maintain and increase the role of Delaware's forests in the global carbon cycle.

Summary – Criterion 5.

Forests in Delaware currently contain over twenty million tons of carbon and this amount has increased with the maturing of our forests. Urban forests, in addition to removing other pollutants, also reduce energy consumption helping to cool urban areas in the summer and warm them during the winter. This helps to mitigate the effects of global climate change, which is directly related to the S&PF Redesign theme to *Enhance Public Benefits from Trees and Forests*. Forest management activities can lead to increased growth rates and increased uptake of carbon in vigorously growing stands. Expanding forested areas in both rural and urban areas – and reducing their permanent loss to development and other land uses – increases carbon sequestration and storage. Maintaining and managing our rural and urban forest resources provide a wide variety of benefits, including carbon sequestration and storage.

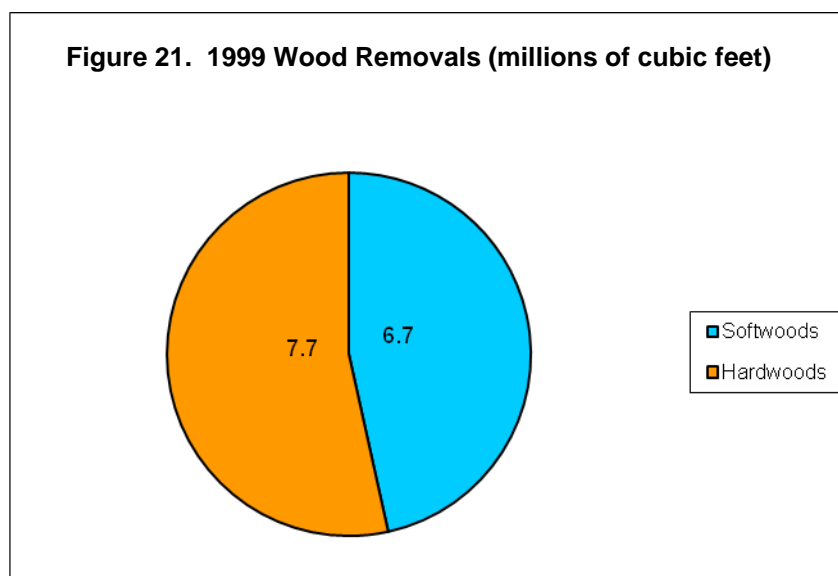
Criterion 6: Maintenance and Enhancement of Long-Term Multiple Socio-Economic Benefits to Meet the Needs of Societies

Importance: Forests provide a wide range of social and economic benefits from timber products to recreation to aesthetics. The markets for these products are a significant sector of our state's economy. Maintaining and growing these markets is vital not only to Delaware's economy but also sustaining the forest land base – owners need to generate sufficient income from their forests to retain their forests. Furthermore, it is important to develop new markets, such as wood energy, to maintain a robust and diverse forest products economy so it is not overly dependent on a single market. Public investment in forests, forest markets, and forest research is also necessary to ensure a sustainable land base and the best information is available to landowners and decision-makers. Addressing all of these issues is necessary to help ensure that Delaware's forests will continue to meet society's needs in the future.

Indicator 12: Wood and wood products production, consumption, and trade.

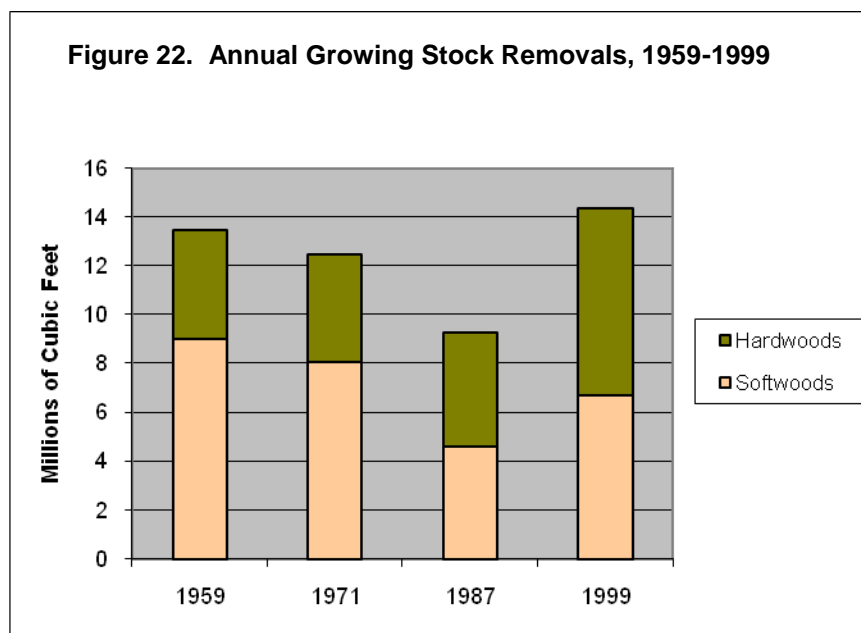
Introduction: Wood products have always been a critical component of Delaware's economy. Lumber remains the primary building material for new houses. Pulp, paper, and other forest products provide many of the household goods often taken for granted. In 1962, the total consumption in the United States of solid wood products, paper, and pulp was 11.6 billion cubic feet. By 1998, consumption of these products had grown to 19.6 billion cubic feet, an increase of 69 percent (McKeever 2002). Delawarean's appetite for wood and wood products continues to grow – it is important that our state maintain a sufficient forest base and the technology to help meet this demand.

In 1999, approximately 14.4 million cubic feet of growing stock were removed through timber harvests in Delaware. Volumes of softwoods and hardwoods were nearly equal (Figure 21).



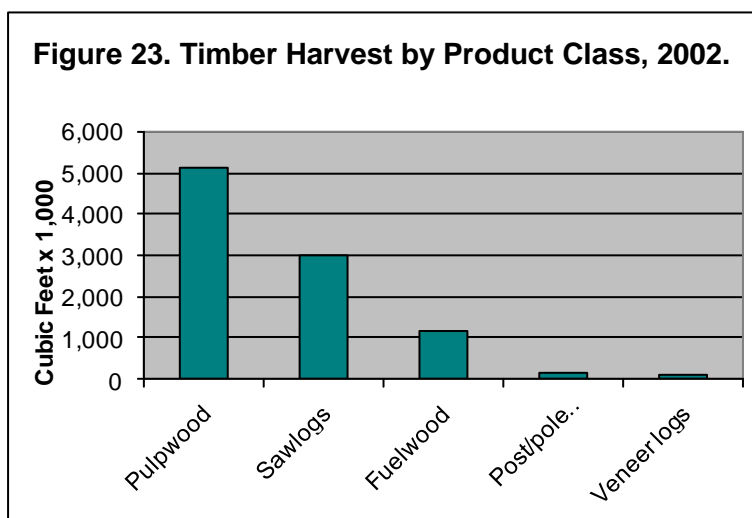
Source: USDA Forest Service Forest Inventory and Analysis.

Historic removals since 1959 have not fluctuated greatly. Annual removals for the last 50 years have ranged from approximately 10 to 15 million cubic feet (Figure 22). This reflects the fact that Delaware's forested acreage has remained fairly constant during this time period, as discussed previously in Indicator 1. The proportion of hardwood to softwood volume has increased considerably, however, due to the replacement of loblolly pine stands by hardwood stands discussed previously. Additionally, the markets for small and poor quality hardwood timber, primarily pulpwood and wood chips for the prison in Princess Anne, Maryland, have increased over the last two decades.



Source: USDA Forest Service Forest Inventory and Analysis.

Pulpwood and sawlogs accounted for more than 85 percent of the total volume harvested in 2002 (Figure 23). The remaining volume consisted of veneer logs, fuel wood, and posts, pilings, and poles. Nearly all of these harvests occur on privately owned forestland; State Forests are the only publicly owned forests that are actively managed for timber production.



Source: USDA Forest Service Forest Inventory and Analysis, Timber Product Output.

The DFS is able to track most of the state's timber harvest through its notification system required by the state's Erosion and Sedimentation Law (Title 3, Chapter 10, Subchapter VI) for all harvests exceeding one acre (see Table 12) Come back to this. On average, approximately 4,800 acres of timber are harvested annually – approximately 50 percent of this total (2,400 acres) are clearcut harvests, 33 percent are selection harvests, and the remainder are pine thinning harvests. While the size, quality, and species of trees vary greatly by harvest, and thus the timber harvest revenue varies depending on these factors, the DFS estimates that these harvests return at least \$4 million each year to landowners. While still significant, the overall timber income has decreased markedly (estimates are at least 30 percent) because the dramatic decrease in timber prices caused, in large part, by the precipitous drop in lumber prices following the collapse of the real estate market and housing industry.

A somewhat unique, and important, market for byproducts from sawmills in Delaware and the entire Delmarva Peninsula is bedding for the poultry industry. Sussex County, Delaware produces more chickens (broilers) than any county in the nation. This requires large amounts of bedding material, much of which is supplied as shavings and sawdust (pine is preferred but hardwood sawdust is also used) from the mills.

It is worth noting that the bulk of the timber harvested in Delaware is processed out-of-state. There are no major sawmills or other wood processing facilities in the state. Four sawmills process pine sawtimber from Delaware – all four are located in Maryland counties adjoining Delaware. Most of the state's hardwood sawtimber is processed by three mills – all located in Maryland – although there are five sawmills, including Amish-owned mills, in southern and central Delaware. These five sawmills specialize in hardwood sawtimber. There are also two small concentration yards in southern Delaware that purchase some pine and hardwood timber. Pine and hardwood pulpwood is supplied to two paper mills – one in Pennsylvania and one in Virginia. Each of these paper mills has a satellite chip mill located on Maryland's Eastern Shore. Figure 24 shows the locations of these mills.

As mentioned previously, there is a market for wood chips for energy production, namely the prison facility in Princess Anne, Maryland located approximately 15 miles south of the Delaware border. Although difficult to quantify, there is a slow increase in the number of portable sawmills in the area, including small, often solar-powered lumber dry kilns. The impact of these niche operations may grow in coming years and the technical assistance needed by these operators is often quite different from that of traditional larger sawmills.

Figure 24. Delmarva Peninsula Mills and Concentration Yards, 2009.



Source: Delaware Forest Service and Maryland Forest Service.

Conclusions: Annual removals of hardwoods and softwoods are approximately equal even though softwoods accounted for only 16 percent of all growing stock in 1999. Hardwood harvests have risen significantly recently with an increase in demand for hardwood pulpwood. The annual softwood harvest cannot continue at this current rate without a significant increase in pine acreage and/or increased production through more intensive management. The majority of the volume harvested falls into pulpwood and sawlog product classes and virtually all of this timber is processed out-of-state.

Indicator 13: Outdoor recreational participation and facilities.

***Introduction:** In addition to forest products such as lumber and paper, forests provide many non-extractive benefits. Public recreation is one such benefit. The recreational infrastructure and the degree to which people are using forests for recreation help us understand the importance of recreational opportunities in our forests.*

Forests offer a wide variety of opportunities for outdoor recreation. Table 12 details public participation in nine outdoor activities; most of these activities occur in part or entirely within forested areas. These estimates were based on a survey of Delaware households, and the number of participants was calculated using Delaware Population Consortium figures for the number of Delaware households and the average household size (2.55 people per household).

Table 12. Outdoor recreation, 2008, age 16 and older.

Activity	Percent participating	Number of participants
Walking and Jogging	85	741,000
Swimming	65	567,000
Picnicking	63	549,000
Fishing	47	410,000
Hiking	46	401,000
Camping	31	270,000
Canoeing/Kayaking	27	235,000
Horseback riding	17	148,000
Hunting	15	131,000

Source: 2008 Outdoor Recreation and Trends Survey.

In 2009 there were more than 540 miles of trails open to the public, an increase of 46 percent compared to 2002. In addition, approximately 200 of these trail miles were open to horseback riding and 443 miles to mountain biking.

Public lands are often used for recreation by the public and many of these publicly owned recreational opportunities occur within forested areas. Publicly protected lands have grown from 126,000 acres in 2002 to over 163,000 acres in 2008. The majority of these lands are within State Parks, State Fish and Wildlife Areas, State Forests, and Delaware's two National Wildlife Refuges. Forest covers about 45 percent of these State and Federal lands, all of which are open for public recreation. Maintenance and enhancement of these facilities is necessary to accommodate Delaware's growing population.

***Conclusions:** Data indicate that recreation in forests is a widely enjoyed activity in Delaware. A well-developed recreational infrastructure, including campsites, trails, and more than 50,000 acres of forest on State and Federal lands, is available to the public.*

Indicator 14: Investments in forest health, management, research, and wood processing.

Introduction: Maintenance of healthy forests requires funding. Surveys for insects and diseases, monitoring of forest conditions, tree planting, and research in forestry all require time and money. Furthermore, landowners and communities require technical forestry assistance to maintain and manage their forest resources. Likewise, forest industries must invest in their operations if they are to remain competitive and continue to provide employment opportunities. Tracking the public and private funds invested in these various operations (forest health, management, research, and wood processing) is a good indicator of the likely success and long-term sustainability of forests and forestry in the state.

Forest Management:

The majority of the public funds invested in forest health and management is provided through the Delaware Forest Service (DFS) within the Delaware Department of Agriculture (DDA). Each year, the DFS receives approximately \$1,150,000 in state (general) funds; most (95 percent) of these funds support 16.5 positions within the DFS. These positions include foresters who provide technical forestry assistance to landowners and communities, assist with wildfire suppression, and manage and maintain the three State Forests. These funds have remained fairly stable throughout the past decade, with a slight increase, although the recent economic downturn has resulted in the loss of two positions and some operational funds.

The DFS also generates income from its three State Forests, primarily through timber sales and cropland leases. These funds, called appropriated special funds (ASF), total approximately \$650,000 annually and support 2.5 positions within the DFS.

The DFS also receives, on average, approximately \$600,000 annually (excluding funds from the Forest Legacy program for land acquisition) from the U.S. Forest Service's State and Private Forestry (S&PF) budget. These funds help the DFS to provide urban and community forestry assistance, forest health monitoring and pest diagnosis, forest landowner assistance, and wildfire mitigation and suppression. Included within these grants are funds for four positions, including four forester positions, as well as monies for operating expenses.

Table 13. Delaware Forest Service Positions and Budget

<u>Fiscal Year</u>	<u>DFS Positions</u>	<u>DFS Budget (\$ thousands)</u>
2001	25 (17.0 GF)	\$1,629 (\$878 GF)
2002	25 (17.0 GF)	\$1,627 (\$891 GF)
2003	25 (17.0 GF)	\$1,719 (\$911 GF)
2004	25 (17.0 GF)	\$1,812 (\$927 GF)
2005	25 (17.0 GF)	\$2,300 (\$956 GF)
2006	25 (17.0 GF)	\$2,573 (\$1,022 GF)
2007	25 (17.0 GF)	\$2,769 (\$1,103 GF)
2008	25 (17.0 GF)	\$2,526 (\$1,187 GF)
2009	25 (17.5 GF)	\$2,789 (\$1,215 GF)
2010	23 (16.5 GF)	\$2,672 (\$1,167 GF)

(GF = General Funds)

Additionally, Delaware provides funds each year to landowners to cost share forest management expenses (tree planting, timber stand improvement, etc.) and communities for tree planting and tree management (pruning, hazard tree removal, etc.) on publicly owned lands. Funds for both

landowner and urban forestry projects total approximately \$75,000. The state of Delaware provides \$37,500 for each program through proceeds from State Forest timber sales (ASF funds), while approximately \$40,000 is available through federal funds. The federal funds for urban forestry projects are provided through the Urban and Community Forestry program within the S&PF budget, while the USDA Environmental Quality Incentives Program (EQIP) allocates \$40,000 for forest landowner assistance.

Since its inception in 1991, the urban and community forestry grant program has provided over \$1.5 million to over 200 organizations for tree planting and tree management projects on publicly owned land throughout Delaware. These grants, matched by communities with either nonfederal funds or in-kind services, have resulted in the planting of over 7,500 trees. Funds are also used to complete street-tree inventories and develop community forest management plans. All of these activities help to sustain our state's urban forest resource.

Landowner cost share programs, through the combination of state and federal funds, have resulted in the planting of thousands of tree seedlings and the improvement of 6,300 acres of forests since 2003. During its lifespan, the Forest Land Enhancement Program (FLEP) offered cost-share payments to landowners for forest management activities including reforestation, site preparation, and timber stand improvement. From FY 2003-2006, FLEP distributed over \$148,000 in payments for practices on 4,100 acres. The state-funded cost share program, established in 2005, has distributed more than \$77,000 for forest management practices on nearly 2,200 acres. With the elimination of FLEP after 2006, the only federal cost share program available for forest management activities was EQIP. The NRCS state technical committee originally allocated higher amounts (over \$40,000) of EQIP funds for forestry activities but they were never fully utilized. This is likely due to a decreased demand in cost shares (fewer forest management activities from loss of forestland and fewer landowners actively managing their forest for timber production), less expensive forest management activities (more reliance on chemicals and natural regeneration and less use of heavy equipment), and the availability of other cost share programs – namely the state-funded program and the now defunct Forestland Enhancement Program (FLEP). The need for federal cost shares may increase with the elimination of FLEP and the potential reduction in state cost share funding if state revenues continue to decline.

Another program that has produced significant increases in afforestation projects is the Conservation Reserve Enhancement Program (CREP) that originated in 1999 as a cooperative agreement between the Farm Service Agency, the Natural Resources Conservation Service, and the State of Delaware. CREP offers cost-share payments and annual rental leases to agricultural landowners for five conservation practices. Practices are designed to improve water quality by establishing buffers along waterways on marginal farmland. Practice CP3A, "Hardwood Tree Planting," involves the afforestation of fields with a mixture of hardwood tree species and some softwood (pine) species. More acres have been enrolled in CP3A than in all other practices combined; currently, over 3,600 acres are under active CP3A contracts. An additional 126 acres of riparian buffers have been established. CREP has been extremely successful in Delaware, although the enrollment of new acres continues to decrease as most of the interested landowners are participating.

Forest Health:

Nearly all of the forest health investments within Delaware are included within the state and federal S&PF funds previously discussed. On average, the DFS receives \$69,000 of base S&PF funding for forest health issues – much of these funds support ½ of a senior forester position dedicated to forest health issues (state funds support the remaining ½ of the position). The DFS

annually monitors for various forest pests and has established multiple, long-term forest health monitoring projects, such as one to determine the effects of bacterial leaf scorch on various red oak species. Staff also complete an annual aerial defoliation survey to check for any significant damage from forest insects. The DFS typically receives additional federal funds for specific forest health projects – such as monitoring for emerald ash borer, Sirex woodwasp, and Asian longhorned beetle; these annual awards are usually \$5,000 - \$10,000. The base forest health funding has remained stable over the past decade while the availability of federal funds for monitoring for specific forest pests has actually increased.

The DFS also works with the DDA Plant Industries section which handles forest pest issues related to the horticultural and agricultural industries and has the authority to impose quarantines within the state for various agricultural and forest pests. The Plant Industries section is also responsible for monitoring the state's gypsy moth population and inspecting the state's horticultural industry for any quarantined forest pests.

Forestry Research:

Forestry research opportunities are limited in Delaware because no university offers an accredited forestry program and there is no National Forest or USFS Research Station in the state. Furthermore, with its small staff (23 positions including only 11 forester positions), the DFS does not have sufficient capacity to implement significant forestry research. The DFS conducts small scale research projects, but they are limited in scope and budget. This situation is unlikely to change with decreasing state budgets.

There is limited federal funding provided for forestry research at Delaware's two land grant universities – Delaware State University and the University of Delaware. Since 1995, Delaware has received between \$60,000 and \$90,000 annually for forestry research through the McIntire-Stennis budget. Prior to FY10, all of these funds were awarded to the University of Delaware. However, the McIntire-Stennis law was changed in 2008 such that the 1890 Land Grant colleges were eligible; therefore, beginning in FY10, Delaware State University will receive a portion of the funds.

Table 14. McIntire-Stennis Funding for Delaware

2000 – \$65,185
2001 – \$64,950
2002 – \$64,857
2003 – \$78,237
2004 – \$78,173
2005 – \$78,317
2006 – \$78,349
2007 – \$99,739
2008 – \$85,710
2009 – \$92,876

Wood Processing:

There is virtually no new investment in (primary) wood processing industries in Delaware. Delaware only has a handful of small sawmills with no paper mills or other solid wood product industries. The existing sawmills are small, use primarily low-grade hardwood logs, and are family-operated. The largest hardwood sawmill in Delaware closed a few years ago. With the current depressed lumber market, additional investment in either the existing sawmills or new ones is unlikely. Furthermore, the number of sawmills in surrounding states that purchase Delaware timber continues to shrink – particularly pine sawmills. In less than 10 years, four pine sawmills have closed on the Delmarva Peninsula; this, combined with the depressed economy and real estate market, has produced a dramatic decrease in timber demand in Delaware. There may be an opportunity, and sufficient pine timber, to open a new pine sawmill in Delaware (or elsewhere on the Peninsula), but this will not occur until the national economy and lumber prices improve dramatically.

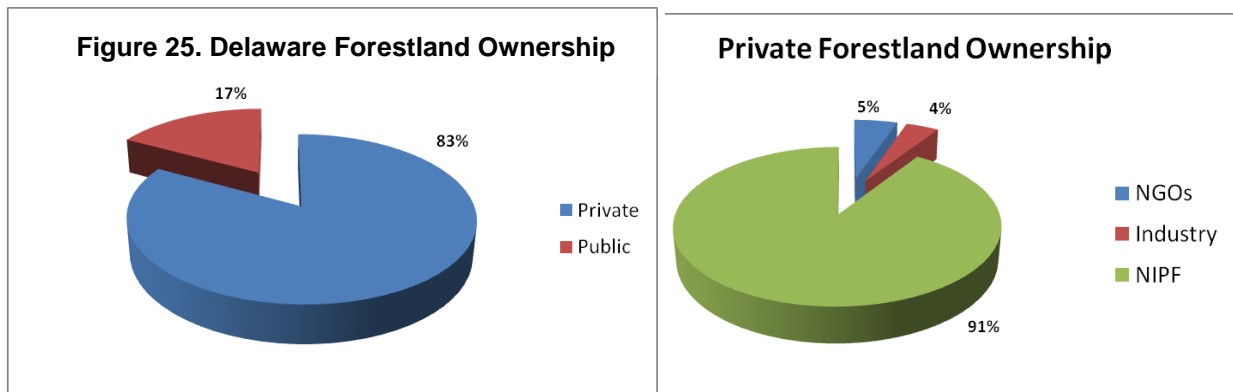
Additionally, while this is not considered wood processing, there are some potential new markets for forest products on the horizon. Delaware is a member of the Regional Greenhouse Gas Initiative (RGGI) and there is work to include forest management, urban forestry, and avoided deforestation as approved forestry offsets for RGGI. Even if these activities are not approved, there is the potential that a national cap and trade program for carbon will recognize these forestry activities. Furthermore, markets for other non-wood services, such as wetland mitigation banking and endangered species banks – collectively referred to as ecosystem services – are emerging. Currently, one investment group is attempting to establish Delaware's first wetland mitigation bank on two former industrial forest properties. The DFS is working with the Pinchot Institute and the Maryland Forest Service to establish the Bay Bank – a voluntary program where private forest landowners can enroll their land for possible ecosystem services payments. Typically, private forest landowners do not have sufficient acreage to access the ecosystem services markets. The Bay Bank project would aggregate these owners such that they could economically gain access to these markets. This work is still in process but offers landowners the opportunity to access new markets for their forest outputs (See Appendix ?? for more information on the Bay Bank Program).

Conclusions: Delaware does not have a forest research station or any universities that have an accredited forestry program; nonetheless, the state receives significant state and federal funding for forest health and forest management. These funds have remained relatively stable and even increased slightly over the past decade. Delaware has also provided funding to communities and landowners for tree planting and other forestry activities; these funds have also remained relatively constant although their sources have changed. There is little investment or research in wood processing industries, primarily because Delaware has few primary wood processors (sawmills and paper mills). There may be an opportunity to site a sawmill in Delaware in the future, but this will not occur until the national economy and lumber prices substantially improve.

Indicator 15: Forest ownership, land use, and specially designated areas.

Introduction: The percentages of public and private sector forestland ownership give an indication of the amount of forestland that is protected from conversion to other uses. Further analysis of private forests, such as the amounts under conservation easements and property tax reduction programs, provides a further understanding of the long-term sustainability of a state's forest resources.

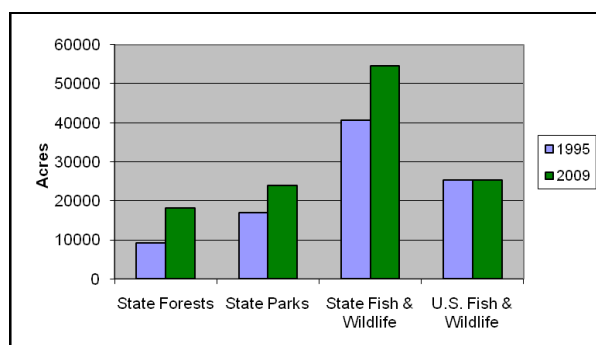
As Figure 25 illustrates, the vast majority (83 percent) of Delaware's forests are privately owned.



Most of the remaining forests are state owned, with some federal and county ownership. Of the 309,000 acres of private forest, non-industrial landowners own 91 percent. Industrial ownership accounts for only about 10,000 acres. Glatfelter Pulp Wood Company is Delaware's sole remaining industrial forest landowner and they have divested over half of their holdings since 1999 and it is likely they will sell the remaining lands within the next decade. The only timber management organization (TIMO) that owns forestland within Delaware is the Forestland Group, which purchased approximately 1,350 acres of former Glatfelter properties; all of these lands have a permanent conservation easement held by the DFS.

Public ownership includes federal lands managed by the U.S. Fish and Wildlife Service (Bombay Hook and Prime Hook National Wildlife Refuges) and state lands managed by several agencies, primarily State Forests, State Parks, and State Wildlife Areas. As shown in Figure 22, state ownership has increased considerably over the last 15 years as private lands have been purchased or donated to the State Forest System, State Parks, and Fish and Wildlife.

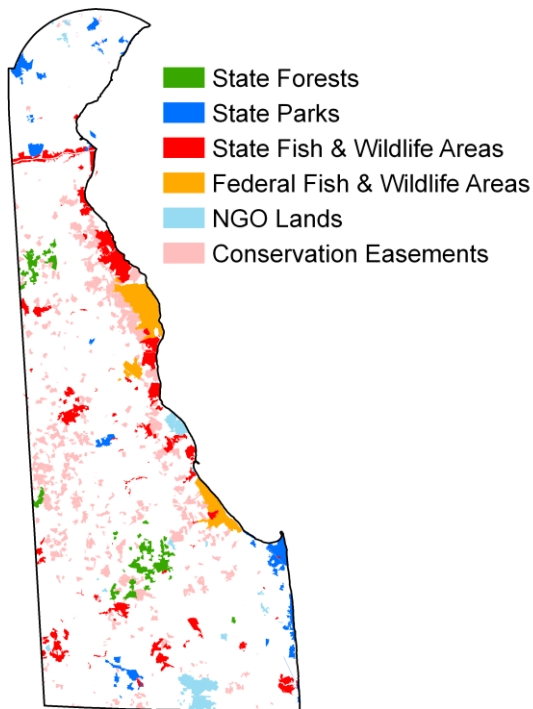
Figure 26. Public ownership (all lands). 1995 and 2009



Source: Delaware State Agency reporting.

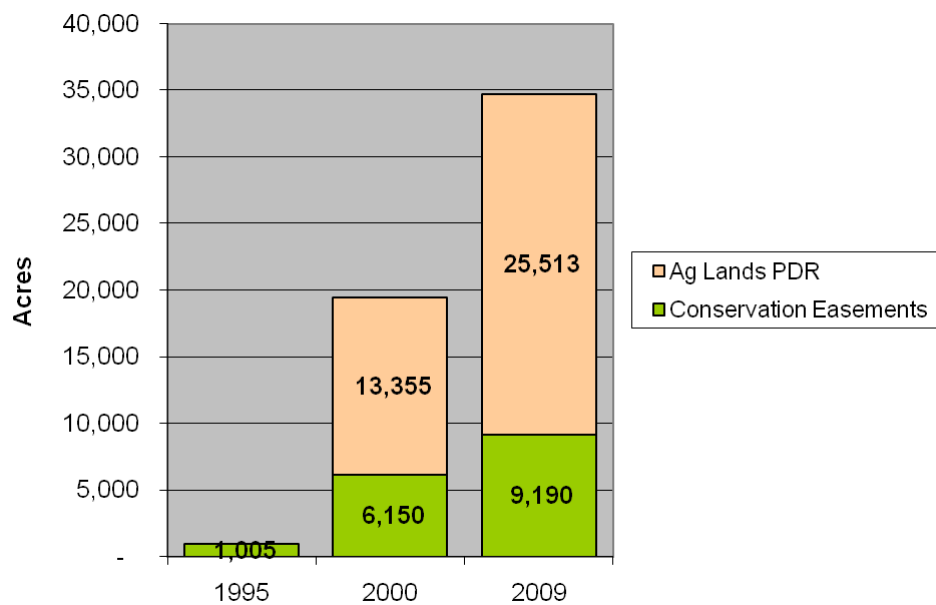
In addition to public ownership, other forestlands are protected through publicly owned conservation easements. Figure 27 displays the total lands in Delaware (forestland, cropland, marshland) protected through public ownership and conservation easements.

Figure 27. Public Ownership in 2005.



The State of Delaware holds conservation easements on private lands through a variety of programs. The Delaware Agricultural Lands Preservation Foundation (DALPF) has the most easements with over 95,000 acres in permanent protection. Of this total, approximately 25,500 acres are forested. While these easements are permanent, they do not prohibit the conversion of forestland to cropland (as long as all federal and state laws are satisfied). The DFS holds permanent easements on over 7,000 acres of forestland; these easements require the owners to maintain the land as forests and follow a forest stewardship (management) plan. Most of these easements are located on working forestlands (loblolly pine plantations) formerly owned by the Chesapeake Forest Products Company; another easement, totaling 908 acres was purchased through the Forest Legacy Program. The remaining easements – approximately 850 acres – were purchased through Delaware’s Forestland Preservation Program. The Department of Natural Resources and Environmental Control, Division of Parks and Recreation, also holds conservation easement on forestland totaling over 1,000 acres; most of these easements are designed to protect biodiversity and unique habitat. Total acreage of conservation easements on forestlands held by the State has increased nearly ten-fold since 1995 (Figure 28).

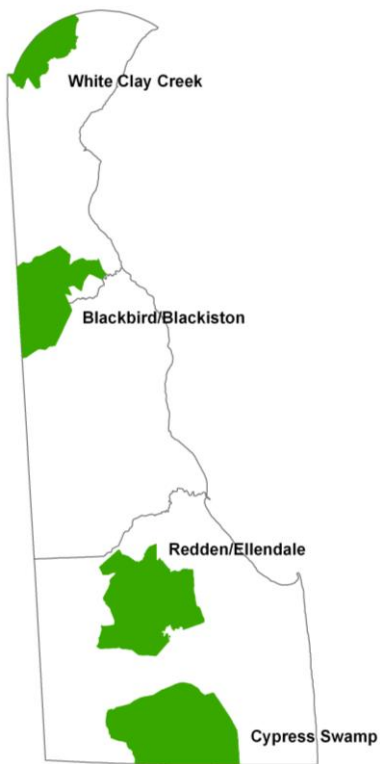
Figure 28. State-owned forested conservation easements, 1995 - 2009.



Source: Delaware State Agency reporting.

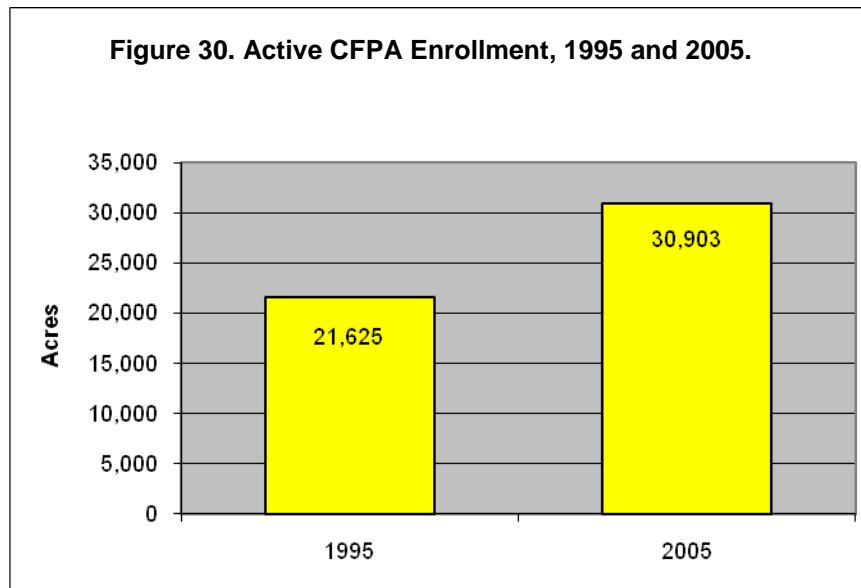
The Forest Legacy Program provides U.S. Forest Service funding for protection of forestlands through outright purchase or through the creation of conservation easements. Funds may only be used in certain geographic areas known as Forest Legacy Areas (Figure 29). As of 2009, 2,032 acres of forests have been protected under the Forest Legacy Program. Seven parcels totaling 1,124 acres have been purchased for Redden State Forest, and one 908-acre conservation easement has been established. (These totals were included in the discussion above.)

Figure 29. Forest Legacy Areas.



Additional forestlands are protected within Delaware through ownership by nongovernmental organizations (NGOs) with environmental protection missions. While many of these lands are not permanently restricted from land use conversion through conservation easements, it is very likely that these forests will remain permanently protected. NGOs own over 16,000 acres of forestland; two organizations own the bulk of these lands – Delaware Wildlands, Inc. (over 11,000 acres) and The Nature Conservancy (over 4,000 acres).

Much of Delaware enjoys extremely low property taxes – some of the lowest tax per assessed value in the eastern United States. Nonetheless, Delaware's Commercial Forest Plantation Act (CFPA) offers a 30-year county tax exemption to landowners with at least 10 acres of forestland and follow a forest stewardship plan. In 2009, 30,903 acres [UPDATE] of private forests were enrolled in CFPA; this is over 10 percent of Delaware's privately owned forestland. The period from 1995 through 2009 saw an increase in CFPA acreage of 50 percent (Figure 30 UPDATE).



Source: Delaware Forest Service.

Additional forestland is enrolled in the state's Farmland Assessment Program that provides a significant property tax reduction (often a complete exemption from property taxes) for agricultural land that generates a minimum amount of gross receipts averaged over a two-year period. Many woodlots that are associated with cropland are included in this property tax program. Currently, the DFS estimates there are approximately 75,000 acres of forestland enrolled in the Farmland Assessment Program. (As of December, 2009 New Castle County reported 7,573 acres and Kent County reported 30,231 acres of forestland enrolled. Sussex County only tracks total acreage (184,626); therefore, assuming 20 percent of these lands are forested – believed to be a reasonable estimate of the forested percentage of farms – yields an estimated 37,000 acres enrolled in Sussex County.) There is no additional requirement, such as a forest management plan, for landowners with forestland within the Farmland Assessment program.

The Sustainable Forestry Initiative (SFI), a program developed by the American Forest and Paper Association, provides certification for forestlands with management plans that meet certain sustainability criteria. The Glatfelter Pulp Wood Company, a private landowner, owns and manages over 8,900 SFI-certified acres in Delaware. Also, the 1,350 acres of forestland owned by the Forestland Group are certified through the Forest Stewardship Council (FSC).

Conclusions: Over 85 percent of Delaware's forests are privately owned; the remaining publicly owned forests are in state ownership with some federal and minimal county/local ownership. Therefore, programs designed for private non-industrial forest landowners will continue to be the most common method to protect forests from conversion to other uses. There are a variety of conservation easement programs that have protected over 30,000 acres of forestland in Delaware. Nongovernmental organizations also have protected significant forested acreage. While Delaware's county property taxes are quite low, the Commercial Forest Plantation Act and Farmland Assessment Act provide property tax exemptions for most of Delaware's forestland. One opportunity to consider is a way to work more closely with landowners with forestland in the Farmland Assessment Program.

Indicator 16: Employment and wages in forestry-related sectors.

***Introduction:** Sustainable forest management requires an economic infrastructure for the production of end-use products from timber. While there are only a few relatively small primary wood processing facilities in the state, Delaware's working forests sustain a number of industries and employ thousands of citizens. Wages must stay competitive to ensure the long-term viability of these industries.*

In 2002 [**Currently being updated – available in spring 2010**] there were more than 2,600 people employed in the forest products manufacturing industry in Delaware. This represents about five people per 1,000 between the ages of 18 and 65. The average rate of pay for these individuals was about \$15 per hour, and they had a total payroll of \$92 million. Most of these jobs are located in secondary wood processing industries; 63 establishments producing a variety of products including furniture, custom millwork, cabinets, and other wood products employed these citizens.

Employment in wood-based industries has risen since 1954, when there were 1,800 people employed in these industries (Table 15).

Table 15. Employment in Timber-related Industries. [**Update in Spring 2010**]

Year	# Employed
1954	1,800
1967	2,200
2002	2,600

Source: U.S. Census Bureau Economic Census.

There are five sawmills located in Delaware, excluding portable mills, and two concentration yards. The DFS also lists 12 Delaware loggers in its primary and secondary wood processors directory.

Nearly all of the foresters in Delaware work for the Delaware Forest Service (DFS). There are a handful of individuals working as procurement foresters; there are no full-time forestry consultants in the state. This situation may be partly explained by the fact that the DFS provides most professional forestry services at no cost (although others from surrounding states work within Delaware). The DFS currently employs 11 foresters as part of its contingent of 23 full-time personnel and one seasonal position. By comparison, in 1984 the DFS employed 13 full-time, permanent staff. Staffing increased steadily over the past 25 years, although the DFS has lost 2 positions since the current economic crisis began in 2008.

The number of certified arborists in Delaware continues to grow. As of 2009, the International Society of Arboriculture (ISA) recognized 81 certified arborists in Delaware; in 1995 the DFS estimates there were less than 10. The number of tree care companies also continues to grow with over 60 now located in Delaware – please note that not all of these companies have a certified arborist on staff. Additionally, the 2007 Census of Agriculture found 47 farms growing nursery stock producing estimated sales of \$47 million. Much of this growth is likely related to Delaware's recent increase in population and expansion of urban areas.

Conclusions: Forest products industries, particularly secondary wood processors, employ thousands of Delawareans and constitute an important sector of the economy. There are limited opportunities for professional foresters – most are employed with the Delaware Forest Service; Delaware has no full-time forestry consultants. The number of urban forestry jobs, such as certified arborists, other tree care professionals, and forest nursery positions has grown.

Summary – Criterion 6.

Forests in Delaware contribute significantly not only to our state's environmental quality but also our economic viability. Despite the fact that nearly all of Delaware's timber is processed out-of-state, these harvests produce a significant return to Delaware's landowners. Annual harvests of hardwoods and softwoods are approximately equal but the level of softwood (pine) harvest is not sustainable given the significant drop in total softwood acreage. Hardwood harvests have increased in recent years with additional demand for low quality timber (pulp and wood energy) although ample supplies remain.

Recreational opportunities abound in Delaware and have increased with the significant additions to state-owned parks, forests, and wildlife areas. A well-developed recreational infrastructure, including campsites, trails, and more than 50,000 acres of forest on state and federal lands, is available to the public.

Public investment in forest health and management has remained relatively constant with a gradual increase in many cases despite the fact that Delaware does not have a forest research station or any universities that have an accredited forestry program. The DFS offers a full range of technical forestry assistance to communities and landowners and some financial assistance for tree planting and other management activities. These funds, a mixture of state and federal sources, have also remained relatively constant although their sources have changed. Such investments help to achieve one of the national themes of the State and Private Forestry Redesign process, namely to *Conserve Working Forest Lands*. There is little investment or research in wood processing industries, primarily because Delaware's have very few primary wood processors (sawmills and paper mills) and this is not likely to change until the national economy improves substantially.

Delaware has invested significant funding to purchase forestland outright and to purchase conservation easements. Over 50,000 acres of forestland are now publicly owned (over 95% state owned) which represents approximately 13 percent of Delaware's forest base. An additional 30,000 acres are in permanent conservation easements. Many of these purchases have occurred since 2000. Most of the privately owned forestland is enrolled in one of two property tax reduction/exemption programs although one of the programs (Farmland Assessment) does not require any forest management by landowners.

Delaware's forest-based industry, while relatively small, significantly contributes to the economy; the secondary wood processors employ the most citizens. Opportunities for professional foresters are limited; the Delaware Forest Service is the largest employer. The number of urban forestry professionals continues to grow as Delaware's expanding population requires additional arborists and tree nursery professionals.

All of these indicators help to ensure that our citizens will continue to enjoy the many benefits and services provided by our forests. Continuing these investments, in a cohesive and strategic strategy, will help maintain and *Enhance Public Benefits from Trees and Forests* – one of the S&PF Redesign themes.

Criterion 7: Legal, Institutional, and Economic Framework for Forest Conservation and Sustainable Management

Importance: A society's laws and regulations often have a profound effect on the long-term sustainability of a state's forest resources. Well-designed environmental laws, regulations, standards, and ordinances can help protect and conserve forest resources, while poorly conceived policies, or the lack of policies, can result in the continuing loss and fragmentation of forests. State and local governments need to recognize the importance of forests and their associated resources and take the necessary steps to maintain and enhance them for future generations. Therefore, it is important to ensure that a state has sufficient policies and laws, as well as standards and guidelines, to address the use and long-term sustainability of its forests while not overly burdening landowners and other forest users.

Indicator 17: Forest management standards/guidelines.

Introduction: Forest management guidelines are used to ensure sustainable management of forests on private and public lands and in urban areas. The Delaware Forest Service (DFS) provides forest management assistance to landowners and communities to help them manage their forest resources. Delaware actively participates in the Forest Stewardship Program, American Tree Farm System, and Tree City USA. The DFS tracks the success of these efforts through multiple performance measures; these measures indicate a steady improvement in rural and urban forest management but further outreach and assistance is still needed.

The DFS provides a variety of technical forestry assistance to landowners, including standards for forest management. One very important standard is a plan that addresses all aspects of their forest resource, including wood production, wildlife habitat, recreational opportunities, and soil and water quality protection. Forest stewardship plans incorporate all of these resources into a long-term management plan for the forest landowner based on his/her goals for the property. By following these plans, landowners help to ensure that Delaware's forests are sustainably managed. Table 16 details forest stewardship plan activity on private lands for the years 1997 through 2008.

Table 16. New Forest Stewardship Plans, 1997-2008.

Year	Acres	# Plans
1997	5,016	104
1998	4,305	64
1999	1,939	38
2000	1,203	27
2001	2,777	57
2002	1,543	31
2003	3,584	69
2004	2,312	39
2005	2,153	29
2006	1,405	31
2007	13,778	22
2008	2,722	46

Source: Delaware Forest Service.

Additionally, the American Tree Farm System operated by the American Forest Foundation recognizes landowners who are committed to the sustainable management of their forests. Landowners must follow a forest stewardship plan for their property that is written by a certified forester and they receive professional assistance when they implement forest management activities. Wood produced from Tree Farms is now recognized by many organizations as certified. There are over 230 participating Tree Farmers in Delaware with nearly 28,000 acres of forestland. Tree Farms are inspected by a certified tree farm inspector to monitor the property and assure plan compliance.

The DFS continues to provide educational opportunities and technical forestry assistance to landowners and attempts to reach these landowners through the media and other avenues (direct mail, Internet, workshops, etc.). One DFS performance measure is to monitor the percentage of timber harvests (on an acreage basis) that follow a forest management plan. While having a forest management plan does not guarantee that a harvest is sustainably implemented and there are certainly excellent harvests on properties that do not have a plan, we believe this is one of the best measures to gauge our success in reaching forest landowners and helping them to sustainably manage their forests. Table 17 summarizes this performance measure, by state fiscal year (July 1 – June 30) over the past 6 years.

Table 17. Percentage of Timber Harvests with a Forest Management Plan
(Excludes timber harvests associated with land conversions)

<u>Fiscal Year</u>	<u>% of Harvests w/Plan</u>
2005	17%
2006	46%
2007	34%
2008	23%
2009	36%
2010	34% (through December)

The data indicates that approximately one-third of timber harvests follow a professionally-prepared forest management plan. National estimates usually range from 10 – 20 percent, therefore Delaware’s performance is above average but much work remains.

The DFS also developed best management practices (BMPs) for forest management activities in 1995, working with landowners, forest industry, nongovernmental organizations, and other public agencies. These BMPs are provided to landowners and forest operators (loggers, timber buyers, etc.) and they describe actions (buffers along waterways, proper water crossings, etc.) to ensure that timber harvests and other forestry activities do not degrade water quality.

Delaware also partners with the State of Maryland in the Maryland/Delaware Master Logger Program. The Master Logger Program is a voluntary, education and (third party) certification program for loggers. Its goal is to provide loggers with comprehensive training and education in the laws, regulations, and practices that are important to the industry. Loggers must complete a set of core courses to become certified and then complete continuing education courses to maintain current status. Core courses include sustainable forest management, timber harvesting, wildlife management, and safety techniques. Loggers who are master loggers have a skill set that allows them to operate at the highest level of professionalism and safety. The master logger program also allows landowners to select operators who are committed to professionalism and high quality,

sound timber harvesting. Currently there are 10 Master Loggers in Delaware and 44 on the eastern shore of Maryland.

As discussed previously, there is the potential for harvesting low quality timber, primarily hardwood species, for energy production in Delaware. This could provide new markets for Delaware's forest landowners. Currently, Delaware does not have guidelines for biomass harvests. Because biomass harvests could use not only low value timber but also portions of trees that are not removed during a conventional harvest (limbs, stumps, etc.), the DFS may wish to consider developing guidelines for these harvests to ensure they do not reduce site productivity or otherwise detrimentally affect these sites.

Delaware's three State Forests are managed with the assistance of forest management plans prepared by staff foresters. The three State Forest management plans were updated in 2006 and address not only timber production, but the other entire suite of forest resources (wildlife habitat, recreational opportunities, threatened and endangered species, etc.) as well. State Parks and Fish and Wildlife Areas are also managed with the assistance of forest management plans prepared by professional foresters. Although some of these lands are not managed for timber production, issues such as invasive species control, threatened and endangered species protection, and forest health are best approached with the help of a long-term forest management plan.

Urban forestry assistance and guidelines are provided to Delaware's communities and homeowners. Delaware participates in the Tree City USA program that recognizes communities that meet four criteria (tree board or commission, tree ordinance, spend at least \$2/capita on tree planting and management, and recognize Arbor Day). Communities that achieve this status are actively managing their urban forest resources. The DFS uses the percentage of Delaware communities that have achieved Tree City USA status as a performance measure to gauge its success in helping cities and towns incorporate urban forest management into their long-term plans and thus sustainably manage their urban forests. Currently, 17 of Delaware's 57 incorporated cities and towns (30 percent) have achieved Tree City USA status. By comparison, in 2000 only 4 communities were recognized. Delaware's current Tree City USA communities are:

Bethany Beach	Bridgeville	Dagsboro
Delaware City	Dewey Beach	Dover
Dover Air Force Base	Fenwick Island	Lewes
Middletown	Milford	Newark
Ocean View	Odessa	Rehoboth Beach
Smyrna	Wilmington	

Management of urban forest resources along public utility rights-of-way is also important to not only protect these resources but also for public safety. The Tree Line USA program, also administered by the National Arbor Day Foundation, recognizes utility companies that meet three criteria for proper management of trees along utility lines. Currently one Delaware company (Delmarva Power) is recognized as a Tree Line USA utility. The three criteria are:

- **Quality Tree Care** - The utility follows industry standards for pruning, planting, removals, and trenching and tunneling near trees.
- **Annual Worker training** - The utility ensures that its employees and contract workers are trained in best practices.
- **Tree Planting and Public Education** - The utility sponsors and participates in a tree planting and public education program designed to expand canopy and educate customers

about proper tree planting, placement, and pruning, including participation in community Arbor Day celebrations.

The DFS also encourages communities and homeowners to utilize certified arborists for any tree care assistance. The DFS has partnered with the International Society of Arboriculture (ISA) to provide training to tree care professionals to help them better manage our urban forests. Currently there are 81 certified arborists in Delaware.

Additionally, the DFS provides forest management information to homeowners. Examples include a list for homeowners of recommended tree species for planting based on tree size (Right Tree for the Right Place) and soil types. As a corollary, the DFS also publishes a list of trees not to plant because they are either invasive or are prone to certain forest insects or diseases. Included with these publications are tree planting and tree care recommendations. Appendix ?? contains a sampling of these publications.

Education, while not a specific forest management standard or guideline, is also an important function of the DFS. Increasing the public's knowledge of the forest resource and its many benefits is vital to the long-term sustainability of our forests. Informed citizens, both children and adults, will help make wise decisions concerning forest policy. The DFS supports the internationally recognized Project Learning Tree (PLT) curriculum administered by the American Forest Foundation. The DFS has an educator on staff who provides PLT training to teachers and other educators as well as a PLT Advisory Committee to help monitor and improve the program. Additionally, the DFS provides wildfire prevention (Smokey Bear) programs to 1st grade students and Arbor Day programs to elementary students to improve students' understanding of forestry issues. There are also education centers and trails at Blackbird and Redden State Forests to further the public's forestry knowledge. One of the DFS performance measures is to track the percentage of elementary schools (public and private combined) that participate in at least one DFS educational program. In FY09, 60 percent of Delaware's 192 elementary schools participated in a DFS educational program. Table 18 has a summary of the PLT, Smokey Bear, and Arbor Day programs in Delaware since 2005.

Table 18. Percentage of Elementary Schools Participating in DFS Educational Programs and Number of Students Participating in Smokey Bear and Arbor Day Programs

<u>Fiscal Year</u>	<u>% of Schools Participating</u>	<u># of Students</u>
2005	56%	9,600
2006	50%	11,100
2007	47%	11,600
2008	49%	11,700
2009	60%	11,900

Conclusions: Delaware, with partnerships with other natural resource organizations, provides sustainable forest management standards to landowners. Tracking the percentage of timber harvests that follow a forest management plan shows that an increasing number of landowners utilize professional forestry assistance, although many landowners have yet to receive assistance. The DFS also partners with other natural resource organizations to provide urban forestry assistance and guidelines to communities, utilities, and tree care professionals. Approximately 30 percent of Delaware's communities include urban forest management in their planning process – an increase from ten years ago. The DFS also provides educational information and recommendations to homeowners to help them better manage their urban trees. Lastly, Delaware

provides educational programs to students and adults to increase their knowledge of the importance of forest resources.

Indicator 18: Forest-related planning, assessment, policy, and law.

Introduction: Laws addressing forest management place boundaries on permissible activities to protect soil and water quality as well as the forest itself. Forest-related planning and assessment are tools through which policy recommendations are made. Solid legal and planning frameworks are necessary to ensure sustainable forest management. In addition, site-specific planning is necessary to promote proper management at the stand and parcel levels.

The Delaware Forest Service (DFS) has completed various forest planning documents in recent years. The Vision for the Future of Delaware's Forests published in 1998 provided an overview of Delaware's forest resources as well as current and future efforts to sustain these forests. A comprehensive Forest Health report published in 2006 provided a status of Delaware's forests based on the 7 criteria and 18 indicators for sustainable forest management used for this state assessment. Additionally, a Forest Legacy Assessment of Need (AON) was completed and accepted by the USDA Secretary in December 1998 that presented a plan and guidelines for Delaware's Forest Legacy Program including the state's four Forest Legacy Areas (Figure 25). Lastly, the DFS completed a comprehensive five-year strategic plan in 2008 with input from a variety of stakeholders, including landowners, communities, nongovernmental organizations, and other public agencies (see Appendix ?? for copies of each of these publications).

Delaware also participates in the U.S Forest Service's Forest Inventory and Analysis (FIA) program. FIA utilizes a series of permanent plots located throughout the state to analyze the forest resources (but not urban forests) including acreage, forest types, forest volume, growth, mortality, and other (wood) removals. This information is valuable not only to the DFS but also to many other parties as well including forest industry and other government agencies. In fact, much of the forest resource data in this assessment is FIA data. Until 2004, the U.S. Forest Service measured the FIA plots periodically – Delaware's forests were measured in 1957, 1972, 1986, and 1999. Beginning in 2004, the U.S. Forest Service began measuring the FIA plots on a continuous basis. Federal funding is available to measure 1/7 of the plots annually; thus, after the first seven years, Delaware's entire data set would be available. Delaware elected to provide state funding to reduce the measurement cycle to five years because land use changes are rapidly impacting our forestland. Additionally, due to Delaware's small size, the estimates from the FIA plots are often based on relatively few observations and thus the values have large confidence intervals. Therefore, Delaware also invested funds to double the number of permanent plots to help produce more precise estimates. 2008 was the final year of the initial five-year measurement cycle; we hope to have updated data very soon.

All of these processes and supporting documents have helped to inform the public about Delaware's forests and provide guidance for future activities. These efforts have helped to garner support for the allocation of state and federal funds to protect strategic working forestlands and to initiate the state's Forestland Preservation Program. They have also contributed information for this statewide forest resource assessment.

The **Delaware Seed Tree Law** (Title 3, Chapter 10, Subchapter V), enacted in 1989, applies to timber harvests of 10 acres or more where 25 percent of the canopy consists of pine and/or yellow-poplar, unless the forest will be converted to another land use (agriculture, development). The law requires owners to make provisions ensuring 400 healthy pine and/or yellow-poplar seedlings per acre following harvest. Reforestation may be attained by planting or, where conditions permit, through natural regeneration. This law was passed due to the significant drop in loblolly pine acreage in the late 20th century and a similar, albeit smaller, decline in yellow-poplar acreage.

Since 2000, an average of 35 harvest operations (averaging 1,955 total acres) annually triggered Seed Tree Law reforestation requirements (Table 19).

Table 19. Number of timber harvest operations affected by the Delaware Seed Tree Law, 2000-2008.

Year	Operations	Acres	Acres Regenerated	
			Planted	Natural
2000	53	3,125	1,960	1,165
2001	31	1,057	934	123
2002	38	1,825	1,645	180
2003	43	2,657	1,994	663
2004	29	2,056	1,197	859
2005	35	2,171	845	1,326
2006	41	2,064	445	1,619
2007	23	1,063	232	831
2008	25	1,578	184	1,394

Source: Delaware Forest Service.

The **Erosion and Sedimentation (E&S) Law** (Title 3, Chapter 10, Subchapter VI), passed in 1994, requires that forest management activities, including timber harvests, protect water quality by eliminating sedimentation and erosion. Operators satisfy the law by using silvicultural best management practices (BMPs) during timber harvest and other activities. The DFS developed and published Delaware's BMPs in 1995 through a collaborative process with forest industry, forest landowners, NGOs, and other government agencies. BMPs are designed to reduce the delivery of sediment to surface waters during harvest. Examples of timber harvest BMPs include proper placement of roads and landings, as well as retention of some trees in sensitive riparian zones. The DFS enforces the E&S law; enforcement options, though seldom required, include cease-and-desist orders and fines of up to \$5,000 per offense.

To monitor forest harvest operations, the E&S law also requires that landowners and forest operators notify the DFS of all timber harvests totaling one acre or more. The application includes a summary and map of the harvest area, including any BMPs planned, and the intended future use of the property (forest, development, agriculture). The DFS reviews the application to ensure that proposed harvests comply with the Seed Tree Law and E&S requirements and makes any necessary revisions to the planned BMPs before approving the permit. Foresters perform site inspections to ensure that the provisions of the harvest permits are met. Details on E&S permitting for the years 2000 through 2008 are contained in Table 20.

Table 20. E&S (timber harvest) Permits, 2000-2008.

Year	Permits	Acres	Inspections
2000	140	6,135	307
2001	111	4,682	286
2002	134	4,106	313
2003	146	5,273	284
2004	123	4,791	290
2005	134	4,941	302
2006	137	4,461	375
2007	134	4,051	297
2008	116	5,246	297

The Seed Tree and E&S laws are Delaware's only two laws specific to forest management. Other than the Seed Tree law – which only addresses pine and yellow-poplar – there are no regulations that address how landowners manage their hardwood forests for silvicultural purposes. This could partly explain the increase in low-quality hardwood species, namely gum and maple, although other events/issues have certainly contributed as well, namely gypsy moth infestations, 1994 ice storm, and the lack of markets for low quality hardwoods.

Delaware law also contains code for urban and community forestry (Title 3, Chapter 10, Subchapter III). This legislation, passed in 1998, formally established an Urban and Community Forestry Program and designated this authority to the DFS. In addition to establishing an advisory council, it also outlines actions for the DFS to expand urban forests and urban forest management, including the authority to develop guidelines for comprehensive community forestry plans, voluntary accreditation programs for tree care, and a community forestry grant program. The law does not, however, contain any specific requirements for communities to manage their urban forest resource.

Delaware law also establishes two advisory councils to help direct and advise the DFS. Title 29 §8107A of the Delaware Code established the Governor's Council on Forestry. This seven-member board, appointed by the Governor, advises the DFS on important issues including forest health, fire prevention, forestry education, and forest management. A parallel group, the Delaware Community Forestry Council established in Title 3 §1034, performs a similar function for the DFS Urban and Community Forestry Program.

Delaware also has legislation that addresses illegal timber harvests. The Timber Trespass law (Title 25, Chapter 14) establishes the penalties for the illegal removal (stealing) of timber from private landowners. The Court determines whether the trespass was intentional or accidental. Intentional trespass entitles the landowner to three times the value of the trees taken, or "triple stumpage." In cases of accidental trespass, the violator must pay the owner for the value of the trees removed plus court costs.

Conclusions: The DFS works to protect forest resources and water quality by enforcing existing laws and regulations. Several documents were published over the past ten years that summarized the status of Delaware's forest resources and helped prioritize the use of various funds and other resources. The Seed Tree Law was passed in 1989 to stop the loss of loblolly pine and yellow-poplar, both extremely important timber species. The Erosion and Sedimentation Law ensures that water quality is protected during forest management operations by utilizing best management practices. Landowners and operators file a permit for all harvests of one acre or more and the DFS monitors these harvests to ensure compliance. Additionally, two advisory councils help to advise the DFS on forestry issues and there is a law to protect landowners from illegal timber harvests.

Summary – Criterion 7.

Forest management standards and guidelines as well as forest policies and laws are important tools to maintain and enhance a state's forest resources. The DFS works with a variety of organizations, including the U.S. Forest Service, American Forest Foundation, and the National Arbor Day Foundation, to provide both forest management standards for rural and urban forest management and technical assistance to help landowners and communities achieve these standards. Tracking the percentage of timber harvests that follow a forest management plan and communities that have

active urban forest management programs shows that an increasing amount of Delaware's rural and urban forestlands are managed with professional forestry guidance, but many have yet to receive assistance. Delaware also has various laws to help ensure the wise use and perpetuation of forest resources, including the Seed Tree Law, Erosion and Sedimentation Law, and Timber Trespass law. The DFS monitors all timber harvests using a permit system to ensure these laws are followed. Two advisory councils also help guide and review forest policies. Many Delawareans, both adult and student, are exposed to forests and forestry issues through the DFS educational programs and State Forest education centers; these programs must continue and grow if future Delawareans are to make wise forest-use policy decisions. All of these efforts help address the three S&PF National Themes – *Conserve Working Forestlands*, *Protect Forests from Harm*, and *Enhance Public Benefits from Trees and Forests*.

4. *Existing and Emerging Benefits and Services*

As presented throughout Section 3 of the assessment (Forest Conditions and Trends), it is obvious that Delaware's forests provide a wide range of benefits and services, both those that we have traditionally recognized (wood products, wildlife habitat, recreational opportunities) as well those that are only now beginning to garner attention (carbon sequestration, water quality and quantity, etc.). The Forest Conditions and Trends section of the assessment provided an overview of these benefits and services. Future strategies and resources will have to consider and address all of the benefits and services that forests supply. Below is a brief summary of the existing and emerging benefits and services provided by our rural and urban forests, beginning with a summary of Delaware's forests.

Forest Cover:

Forests cover approximately 30 percent of Delaware (371,000 acres). This acreage has remained relatively constant during the last century but is beginning to decrease. Over ¼ of Delaware's forests are protected, through public ownership, conservation easements, or nongovernmental organization (NGO) ownership.

While a significant portion of our forests are protected, the remainder is becoming increasingly fragmented. A comparison between 1937 and 2002 aerial photographs found that the number of large forested blocks (250 acres or more) decreased by [YY] percent. The majority of our state's forests are privately owned and the average forest ownership continues to decrease, from over 30 acres per owner in 1975 to less than 10 acres today. This fragmentation and outright loss of forestland is expected to continue; from 2002 through 2009 nearly 16,000 acres of forestland were located within parcels proposed for future development.

Delaware's forests are also aging – with an increasing percentage of trees in older, larger size classes. Furthermore, the species composition is also changing with more hardwoods – particularly red maple – and fewer conifers (loblolly pine).

Delaware's urban tree canopy varies greatly among our municipalities, ranging from a low of 3 percent to a high of 74 percent; the statewide urban tree cover is just under 18 percent within municipal areas and just under 17 percent when other urbanized areas (outside municipal boundaries) are included. Like rural forests, urban forests provide numerous environmental benefits including carbon sequestration, water quality enhancement, energy savings, and controlling stormwater runoff.

Biological Diversity & Wildlife Habitat:

Delaware enjoys a significant variety of forest species and types in a relatively small geographic area. Delaware is the northern extreme for certain southern plant species, such as loblolly pine and baldcypress, while some northern species are not found south of Delaware, except at higher elevations (sugar maple, basswood, hemlock). Delaware's forest interior habitats (both wetland and upland) support the greatest diversity of native vascular plants than any other specific habitat type with upland forests the most species-rich forest type. Specifically, 450 taxa (species and varieties) are considered forest interior species in Delaware and 260 of these are considered upland species. Two forest interior plant species are federally listed by the U.S. Fish and Wildlife Service – swamp pink (LT, *Helonias bullata*) and small whorled pogonia (LT, *Isotria medeoloides*).

Over 900 animal species are native to Delaware and over 800 of these species are still found in Delaware. Of the 45 species listed as State Endangered, 11 are forest dependent. Additionally, there are 113 native bird species that rely require forested habitat and 8 of these are considered State Endangered. The Delmarva fox squirrel is the only terrestrial mammal in Delaware listed as a federally endangered species and it requires forested habitat.

Additionally, as previously discussed, some of Delaware's forest communities have experienced significant declines in acreage. Loblolly pine and wetland forest types (baldcypress, etc.) have experienced significant acreage decreases due to harvesting and drainage. Delaware's forests are becoming older with larger trees, and thus, fewer younger stands containing saplings and seedlings. If this trend continues, it could lead to reduction in habitat for certain animal species.

Forest Products/Economic Contribution:

While there is no current, statistically-valid data on the contribution of the forest products industry to Delaware, it is certainly a significant component. In 2002 **[Will need to update in Spring when new data is available]** more than 2,600 people were employed in the forest products manufacturing industry in Delaware, representing about five people per 1,000 between the ages of 18 and 65. The average rate of pay for these individuals was about \$15 per hour, and they had a total payroll of \$92 million. Most of these jobs are located in secondary wood processing industries; 63 establishments producing a variety of products including furniture, custom millwork, cabinets, and other wood products employed these citizens.

While there are very few primary wood processors in Delaware (such as sawmills), processors in adjoining states purchase a substantial amount of timber in Delaware, providing significant revenue to Delaware's forest landowners. Approximately 4,800 acres are harvested annually – 2,400 acres by clearcut, 1,500 acres by selection harvests, and 900 acres of pine thinning (pulpwood). The DFS estimates that these harvests generate at least \$4 million of income for landowners.

Furthermore, urban forests also contribute jobs to Delaware's economy. The number of tree care companies is growing as Delaware continues to urbanize. There are now 81 certified arborists in Delaware. Nursery farms generate an estimated \$47 million in sales.

There is also an opportunity for new markets for wood, including urban wood. The growing amount of low quality (primarily hardwood) timber is a potential supply for bio-energy. Wood could help to achieve renewable energy goals and provide additional returns to landowners and timber harvesters. Additional research is needed to more accurately estimate the amount of wood that is available for this market.

Soil and Water Quality Protection and Enhancement:

Delaware has significant water quality challenges. Approximately 88 percent of Delaware's rivers and streams do not fully support swimming use and 97 percent do not support fish and wildlife use. Additionally, 44 percent of Delaware's fresh water ponds and lakes do not fully support swimming use and 89 percent do not fully support fish and wildlife use. The cause of impairment in most cases is an excess of nitrogen and phosphorus.

Forests are widely recognized as the land use that is most beneficial for water quality; they provide multiple benefits and services that improve water quality (part of the suite of non-consumptive benefits often called ecosystem services). Maintaining and expanding forest cover is a goal for many water pollution control strategies. Creating forestland (e.g., afforestation) from a different type of land use reduces the amounts of nitrogen and phosphorus that reach streams and

groundwater. Riparian buffers help filter and clean our surface waters. Forest cover also helps improve surface waters that supply municipal drinking water reservoirs. There are two drinking water reservoirs in Delaware – both in northern New Castle County.

Forests also play a critical role in Delaware's groundwater recharge by cleaning this water before it enters the aquifers. Forests comprise approximately 25 percent of Delaware's 119,000 acres of excellent groundwater recharge areas. These areas provide much of the groundwater to recharge Delaware's underground aquifers – the state's primary water supply for all purposes.

Wetlands provide a wide range of valuable functions, including slowing water runoff and trapping sedimentation and filtering pollutants before they reach streams and other waterways; forested wetlands are highly valued for all of these benefits in addition to the valuable habitat they provide for many species of wildlife and plants. There are an estimated 147,000 acres of forested wetlands in Delaware. A particularly important forested wetland type is the Coastal Plain seasonal pond. These seasonally flooded wetlands are found throughout Delaware but particularly in southwestern New Castle County and northwestern Kent County. In addition to the water quality benefits and groundwater recharge, they provide habitat to a variety of state and globally rare plants and animals.

Urban forests also provide significant water quality services. They filter and clean water leaving urban sites. They also help control stormwater runoff by slowing these waters and reducing their impacts on waterways. Many studies have found that well positioned tree plantings, such as around catch basins and stormwater ponds, can reduce the water flow thereby decreasing the potential for flooding during storm events and reducing the amount of land needed for these retention ponds.

Carbon Sequestration\Climate Moderation:

The increase in carbon-containing gases in the atmosphere is widely believed to lead to an increase in global temperatures. Trees combat this effect because they sequester carbon and store it within their stems, roots, etc. Currently, Delaware's forests store approximately 21 million tons of carbon (including 1.3 million tons in urban forests). This amount is increasing because Delaware's forests are, on average, aging and thus increasing in size. While the carbon market is still emerging in the United States, prices are expected to bring at least \$3 per ton; therefore, one could argue that Delaware's forests have currently stored at least \$60 million of carbon from the atmosphere.

Furthermore, forests help moderate climatic effects at the local scale. Riparian forested buffers moderate the water temperatures within streams, thus protecting fish and other species that use these waters. Urban forests reduce energy consumption by cooling urban areas in the summer (shade) and providing windbreaks during the winter. Urban trees in New Castle County save an estimated \$403,000 annually in residential building energy costs, including \$183,000 within the City of Wilmington.

Forests also remove other pollutants that degrade our atmosphere. Studies estimate that Delaware's 7.1 million urban trees remove over 1,700 metric tons per year of pollutants, including 242 tons of nitrous oxide, 221 tons of sulfur dioxide and 744 tons of ozone. This pollution reduction is valued at \$13.5 million annually.

Recreation:

Forests offer a wide variety of opportunities for outdoor recreation. Of Delaware's top 9 recreational activities, at least 6 occur in forested settings. Over 2 million people in Delaware annually participate in these 6 activities (walking/jogging, picnicking, hiking, camping, horseback

riding, hunting). There are over 540 miles of trails open to the public in Delaware, an increase of 46 percent compared to 2002. In addition, approximately 200 of these trail miles are open to horseback riding and 443 miles to mountain biking. Nearly all of these trails traverse forested areas. Forests are vital to Delaware's recreation and tourism industries and to our quality of life.

5. *Issues, Threats, and Opportunities*

The DFS used two processes to identify the highest priority issues, threats, and opportunities for Delaware's forests. First, the DFS completed a comprehensive five-year strategic plan in 2008 through a facilitated process with forty participants representing a variety of stakeholders, including other public (state, federal, local) agencies, landowners, nongovernmental organizations, consultant foresters, forest industry, and recreationists. Through this effort, the stakeholders identified the critical issues facing Delaware's forests and then goals and objectives for the DFS to address in the next five years (2009-2013).

Second, Delaware's Forest Stewardship Committee participated in a facilitated process in 2009 to identify issues, threats, and opportunities facing our state's forests. The committee started with the issues identified during the strategic planning process, added any additional issues, and then specified threats and opportunities. The result was very similar to the outcomes of the strategic planning process.

Lastly, once the issues, threats, and opportunities were drafted, the DFS shared them with other stakeholders through individual visits and on the Internet to determine if this list was appropriate or if changes were necessary. Based on this input, the final list presented below was completed. Appendix [insert] includes a brief review of the processes and the complete list of organizations involved in this process.

a) **Issues**

Issue 1: The public must understand the importance of forests and forest management

While most citizens appreciate forests, most do not understand the wide range and depth of benefits our forests provide. Furthermore, many Delawareans do not understand that forest conservation and sustainable forests require public investment, both financial and technical assistance. Credible, current, easy-to-understand information and ongoing education – both student and adult – are needed for the general public to understand the intricacies of forest management and the techniques and practices necessary to achieve the goals of management. Often sound management techniques are not aesthetically pleasing and this issue must be addressed in forest management education.

Issue 2: Landowners must have diverse, stable forest markets.

A stable, robust and diverse market for forest products, not only timber but also other potential markets, such as carbon and bio-energy, is necessary to help achieve sustainable forest management. Landowners must have the ability to generate income from their forestland; otherwise, they are much more likely to convert their forestland to other uses, such as development. This is particularly evident in Delaware as proposed developments from 2002 – 2009 have included approximately 16,000 acres of forestland – six percent of our remaining unprotected forests. This demand for new homes, coupled with the recent downturn in timber prices, is increasing the pressure on forest landowners to consider converting their forests to other land uses.

Furthermore, Delaware needs a diverse forest market, one that has traditional industries (sawtimber and pulpwood) and emerging markets – such as bio-energy, carbon, and other ecosystem services. A robust forest market should also provide demand for all types of timber – not just the high quality species and stems – thereby helping landowners to sustainably manage their forests. Currently, there is an overabundance of low quality hardwood in Delaware; this lack of market has contributed to the proliferation of low-valued red maple and gum forests because these species are left during most timber harvests. Developing markets for these species would help foresters and landowners establish a better mix of tree species, both for wood production and wildlife habitat.

Markets for non-wood products are also important. Currently hunting leases are the primary non-wood market for forest landowners; however, emerging markets are on the horizon such as carbon credits and other ecosystem services. Establishing state and regional policies that include forests and reward forest management is vital to developing new markets for landowners. Furthermore, niche markets can also benefit landowners, such as Shitake mushroom production and even agri-tourism. Instituting policies that foster a diverse and robust forest market is necessary to retaining forestland, particularly privately owned forests, and sustainably managing them for the long-term.

Issue 3: Delaware's forests are increasingly fragmented, parcelized, and affected by invasive species.

Delaware has more forestland than it did a century ago; however, Delaware is once again losing forests – primarily to development. From 2002 through 2009, 16,000 acres were included in proposed developments. While not all of these projects will occur, it is very likely that most of these forests will either disappear or will be fragmented so that they no longer provide many of the services that we now enjoy. With increased population also comes more landowners and smaller forest ownerships. The average forest ownership is less than 10 acres, compared to over 30 acres just three decades ago. This increasing number of forest landowners presents challenges to public agencies as they attempt to help more landowners with fewer staff and reducing budgets. Public managers will have to rely on new approaches and new partners to reach this growing landowner base.

Smaller forested parcels also increase the amount of forest edge and usually increase the chance for the establishment of invasive plants. While the overall impact of invasive species in Delaware's forests is usually unnoticed, their cumulative effect, particularly in urban forests and forests at the rural/urban interface, is significant and growing.

Issue 4: Many rural and urban forests are not sustainably managed.

Forestry professionals are keenly aware that most private forest landowners do not seek professional forestry assistance (or are not aware of this availability) for managing their woodlands. Furthermore, many landowners only consider their short-term, financial return when selling their timber – even if this option produces a poorly stocked forest. This practice of “high-grading” (harvesting the best timber and leaving the rest) is all too familiar and will not sustain forests – for either their wood products or other resources – for future generations. This situation is compounded in Delaware by the lack of markets for low quality timber (primarily hardwoods).

Urban and community forests face similar challenges. Many cities and towns do not have sufficient expertise or budgets to inventory their street trees and other publicly owned

forests or develop a management plan that outlines their long term goals and objectives for these areas. Often urban forestry budgets are the first to be cut or reduced during difficult economic times. Community leaders and citizens need to understand the importance of forests not only aesthetically but for the numerous environmental benefits they provide (improved water quality and quantity, enhanced recreational experiences, reducing energy costs, reduced stormwater runoff, etc.).

Issue 5: Sufficient financial and technical assistance available to forest landowners (urban and rural).

As with any asset, landowners and communities need professional and affordable assistance for their forests and many landowners do not possess the expertise or experience to manage their forestland. Similarly, urban forests are an important component of cities and towns and many communities do not have forestry professionals on staff to manage these resources. Foresters can help both landowners and communities develop a plan for their forest resources and help them execute that plan. Having access to foresters and arborists helps to ensure that our rural and urban forests are thriving and providing the numerous benefits we all enjoy. Technical assistance not only benefits the forest landowner but also helps to ensure that our forests are sustainably managed for future generations.

Financial assistance is also necessary to help landowners complete forest management practices. Forest management typically produces revenue sporadically and often it is many years, if not decades, between timber harvests – particularly for landowners of small woodlots. Financial assistance, such as cost shares for forest management activities, helps to ensure that landowners can and will complete non-income generating activities, such as timber stand improvement, wildlife habitat enhancement and water quality protection activities. Furthermore, many owners acquire woodlands that have been poorly managed in the past. As these landowners proceed to re-establish sound management practices in their newly acquired woodlands, they often find that the cost of these practices can be quite substantial, depending on the degree of neglect or mismanagement in the past. Funding also benefits cities and towns – often providing the money needed to purchase trees for planting, complete an inventory of the community’s trees, or secure an arborist for pruning and other tree care issues. Financial assistance combined with technical advice is a cornerstone for sound forest management.

Issue 6: Delaware’s diversity.

Despite Delaware’s small size, there is a wide diversity of land use, ideas, and interests within the state. There is an attitude of “downstate versus upstate” for areas south and north of the Chesapeake and Delaware (C&D) Canal. This arose from the urbanized, industrial areas in the north versus the more rural, agronomic economy in the south. This attitude has moderated with the increasing development in the southern part of the state, particularly along coastal areas. Nonetheless, there is still an urban versus rural mentality in many areas of Delaware. The dramatic increase in development has also exposed another somewhat contentious argument in the state. Many Delawareans strongly endorse private property rights; however, the rapid increase in development and suburban sprawl has caused some Delawareans to support tougher land use law and zoning. This conflict is likely to continue into the future. This confrontation also represents another factor in Delaware’s diversity, specifically the increasing number of retirees and others who have recently moved to the state. Many of these relatively new Delawareans are the citizens advocating changes in land use policy that could restrict private property rights. Thus, there are some attitudes of “locals” versus “outsiders.” There are also geographic differences within Delaware, with

the Piedmont located in the very northern part of the state and Coastal Plain throughout its remainder. While all of these attitudes exist, none rise to the level of extreme; in fact, there is often an aversion by Delawareans to confrontation and “making enemies.” Perhaps this is a result of Delaware’s small size – everyone knows everyone else or their friend or relative, so confrontation is avoided. Nonetheless, this diversity provided the foundation for the laws and regulations that govern Delaware’s forests and it will impact any future efforts to revise or develop new policies.

b) **Threats**

1) *Forest Health* - Fragmentation, parcelization, invasive plants, insects, and diseases threaten the long-term health and sustainability of our forests.

As discussed previously, Delaware’s forests – rural and urban – face a wide range of issues that threaten their long-term health. Our forests are increasingly fragmented by development and our remaining forests are divided (parcelized) among more landowners. Six percent of our remaining unprotected forests were included in proposed developments from 2002 to 2009; this trend is not sustainable. Forest fragmentation causes not only forest management challenges, but also produces other effects that are less evident. For instance, it increases the amount of forest “edge” which often leads to the introduction of invasive plants and reduces the habitat for certain interior forest-dwelling species. In addition to the loss of large, contiguous forested areas, there is also a loss of forested corridors (100 to 300 foot wide strips) that connect larger blocks of forestland. These areas provide protected travel corridors for many wildlife species and are often located along waterways, thus providing water quality protection.

Invasive species (plants, insects, and diseases) have also impacted Delaware’s forestlands. Gypsy moth, Dutch elm disease, and chestnut blight are three examples of non-native species that have severely impacted certain tree species within Delaware. While there are no known significant recent introductions of pests to Delaware, there are several located in surrounding states that could potentially impact our forests, such as the Asian longhorned beetle and the emerald ash borer. Invasive plants continue to spread throughout our forests, particularly urban forests and those on the rural/suburban fringe. These plants do not have as dramatic visual impact on our forests as some insects and diseases, but their cumulative impact is significant and often severe.

Additionally, there are native species that are now detrimentally impacting our forests. An overpopulation of white-tailed deer has begun to degrade Delaware’s forests – particularly hardwood forests in northern Delaware. While the Division of Fish and Wildlife has taken several steps to curb this population, there are still portions of the state that have significant overpopulations. This situation is compounded by a decline in the number of hunters in the state. Bacterial leaf scorch (BLS), once considered a relatively minor nuisance for urban forests, is now leading to the death of several red oak species throughout Delaware.

Future efforts must address all of these factors to help ensure the long-term health and viability of Delaware’s forests and help us meet one of the national State and Private Forestry objectives – *Protect Forests from Harm*.

- 2) *Lack of Forest Markets* – markets for traditional forest products (pulpwood and sawtimber) have decreased dramatically in Delaware and the surrounding region and there continues to be a lack of markets for low quality hardwood timber. There is potential for new markets for non-consumptive uses (carbon, wetland mitigation, etc.) but these have yet to develop.

Delaware's landowners need viable and stable markets for their forest products; many landowners will sell or develop their forestland if they cannot generate sufficient income through forest management. The recent economic downturn has further accelerated the decline of traditional forest products markets on the Delmarva Peninsula. The number of sawmills is approximately half of the total from just 15 years ago and this includes the closure of the largest pine sawmill in the region. Pulpwood markets have remained relatively stable but there are only two mills that purchase pulpwood in Delaware and with the continuing decline of the national pulp market, there is the chance that one of these mills could stop purchasing wood in Delaware. Therefore, it is important that Delaware work with its surrounding states to foster new markets, both for traditional products and nontraditional products and services. Bio-energy is a developing market and this could provide new demand for low quality hardwoods. Markets are also emerging for carbon sequestration, wetlands mitigation and even endangered species mitigation and other "ecosystem services" but much work remains to bring them to fruition.

Lack of robust and diverse markets is not only a threat to forest landowners but to our forests. Without markets, we cannot achieve one of the State and Private Forestry national objectives – *Conserving Working Forestlands* or the long-term, sustainable management of our forests.

- 3) *Unsustainable Forest Management* – many of Delaware's urban and rural forests are not sustainably managed. Their owners do not seek (or are unaware of) professional forestry assistance. Markets are not available for low quality trees so they are left behind during timber harvests to seed the next crop; repeated "high grade" harvests eventually leads to a poorly stocked forest with no high-quality trees for future harvests. Many cities and towns do not have the expertise or the funds to retain forestry experts to manage their urban forests and incorporate urban forestry concepts into land use planning. All of these factors, combined with forest loss and fragmentation, contribute to unsustainable management of our forests, which affects the ability of our forests to provide the wide range of benefits that we all enjoy and require to sustain our quality of life. Without sustainable management, we cannot meet the national S&PF objectives to *Enhance Public Benefits from Trees and Forests* and *Conserve Working Forestlands*.

Fortunately, the percentage of Delaware's forests that are not well managed is decreasing. Efforts to educate communities, landowners, and forestry operators (loggers, equipment operators, timber buyers, etc.) about forest and forest management are making an impact. Programs to inform the general public about forest management are also increasing. However, there is room for improvement. Future efforts by the DFS and other natural resource agencies should explore methods to reach more landowners and communities while confronted with decreasing budgets and staffing. Additionally, addressing another threat – lack of forest markets – will help to combat this threat; having diverse and stable markets for forest products and services will help landowners

keep their forests as forests. Maintaining a critical mass of forestland – rural and urban – and working to ensure they are sustainably managed for a variety of benefits is vital to our quality of life.

c) **Opportunities**

- 1) *Increase public awareness and understanding of the importance and need for forests and forest management through education of both children and adults.*

In order to protect and sustain our forest resources, the public must understand and value the importance of these resources. This process starts with educating our citizens, not just forest landowners and forest operators (e.g., loggers, timber buyers) but community leaders, land use planners, legislators, educators, forest users – everyone. Reaching the entire public is a difficult task, so a strategic, prioritized approach is necessary. Some examples include:

- **Children:** Incorporate environmental education into curriculum, such as through Project Learning Tree (PLT). Encourage outdoor classrooms at schools and assist with incorporating these classrooms into the schools' curriculum, such as tree planting projects, monitoring water quality, etc. Also, investigate the possibility of required classes for students in natural resources studies.
- **Adults:** Provide educational opportunities – both in the classroom and on the Internet – for a variety of forestry issues including: forest management, intergenerational transfer, and tax information. Similarly, develop urban forestry-based educational programs for community leaders, civic associations, and homeowners on topics such as tree care, incorporating trees into land use planning, environmental benefits of urban forests, etc.

- 2) *Protect a sufficient forest base to ensure the perpetual production of forestry outputs – timber, wildlife habitat (including rare & endangered species habitat), recreational opportunities, water quality protection, etc., as well as a representation of the various forest types found in Delaware.*

Forests provide a plethora of environmental and economic benefits and it is crucial that Delaware maintain a sufficient amount of forestland to perpetuate these benefits. A full representation of the various forest types (cypress swamps, pine forests, bottomland hardwoods, etc.) is needed to provide the habitat necessary for various plant and animal species. This process could also identify forests that are important for environmental values – such as wetlands, riparian forests, wildlife habitat, etc. – and for timber production (working forests). Additionally, it would identify where strategic afforestation could provide significant environmental benefits, such as connecting forested blocks, creating and expanding forested corridors, buffering headwaters of an important waterway, etc. Communities also need adequate urban tree cover to provide quality of life and environmental benefits; municipalities and community groups should set urban tree canopy goals and consider prioritizing tree planting where it will provide multiple benefits – such as improving water quality. Some opportunities to achieve these objectives include:

- Work with other natural resource agencies, landowners, the forest industry, etc., to develop goals for forestland protection and conservation in Delaware, such as the identification of protection strategies for Delaware's various forest types and riparian forests protection and enhancement, and the control of invasive species (plants, insects, and disease) and white-tailed deer.
- Maintain and increase funding – public and private – for conserving priority forestlands through conservation easements, and in high-priority cases, fee simple purchases. These programs should protect both working forestlands and forests targeted for their high environmental values.
- Enhance incentives for landowners to maintain their forestland – such as property tax reductions, payments to protect the high priority forests, etc., and establish forestland to achieve high priority environmental benefits.
- Incorporate forests and forest benefits into land-use planning processes to help decrease the rate of forest fragmentation in the state.
- Incorporate urban tree canopy goals into municipal plans. Work with municipalities and community groups to set urban tree canopy goals and identify priority areas for maintaining and expanding urban forests.

3) *Maintain adequate and diverse forest markets for landowners to earn a satisfying return on their investment.*

Most forest landowners must earn income from their forestland, or have the potential to earn income, if they are to retain their forests as forests. A stable, robust forest market is vital to the long-term sustainability of forestry and forestland. To that end, there are opportunities to help sustain and expand forest markets:

- Improve and refine the state's forest inventory by working with the U.S. Forest Service and other partners to develop better acreage estimates of the various forest types/species (loblolly pine, baldcypress/Atlantic white-cedar, red and white oak, etc.) and the amount of wood available for various markets – such as low quality hardwoods for bio-energy.
- Work with Delaware's existing wood processors to help ensure their long term profitability.
- Promote and facilitate new markets for wood products – such as bio-energy – and ensure these markets are properly sized for the supply available (including working with forestry agencies of adjoining states).
- Promote and facilitate non-consumptive forest markets – such as carbon credits for forest management and urban forests (not just afforestation), endangered species bank, and wetland mitigation banks – commonly called ecosystem services.

4) *Sustainably manage Delaware's rural and urban forests.*

Ultimately, we must not only maintain sufficient forest acreage but also sustainably manage those rural and urban forests if current and present Delawareans are to enjoy all of the many benefits we receive from forests. Furthermore, most of these forests will be privately owned (or in the case of urban forests owned by homeowners or communities); therefore, these landowners must have the knowledge and ability to manage their forests so that we all benefit. We must seize the opportunities we have to achieve this goal, including:

- Provide technical forestry assistance to landowners, homeowners, and communities through multiple avenues (Internet, group sessions, train-the-trainer, site visits, etc.); this assistance should also address land transfer/estate planning.
- Work with other organizations (public and private) to maintain and enhance cost-share and incentive payment programs, particularly for landowners to conduct high-priority forestry activities and forest management activities in high-priority focus areas.
- Develop other incentives to help conserve and expand forests – such as tax incentives, etc.
- Maintain, encourage and foster new markets for forest products and services.
- Ensure volunteer fire companies are well trained and prepared for wildland firefighting.
- Continue to monitor for forest pests – native and non-native – and prepare for the arrival of new pests.

6. *Rural Priority Landscape Areas*

1. OVERVIEW

The Farm Bill⁴ requires each state to complete a Statewide Forest Resource Assessment or “State Assessment” and Statewide Forest Resource Strategy or “Resource Strategy” to receive funds under the Cooperative Forestry Assistance Act. State Assessments are intended to identify key forest-related issues and priorities to support development of the long-term Resource Strategy. All States are required to complete a State Assessments and Strategies document by June 2010. A primary goal of this process will be to prioritize the allocation of Federal funds in the future.

In order to complete the prioritization process, Geographic Information System (GIS) technology was used. GIS is sophisticated computer software that allows complex analysis of geographic data on standard desktop computers. The Delaware Forest Service (DFS) has routinely used GIS technology since 2000 for a variety of purposes, and all DFS foresters have been capable GIS users since 2005. Therefore, DFS was pre-positioned to carry out this complex analysis without additional software or training.

The GIS analysis used for this study involved the overlay of 23 layers of data. Some layers were recommended by U.S. Forest Service (USFS) guidelines. Other layers were added by DFS staff because they were clearly relevant in Delaware. A few additional layers were incorporated based on recommendations made by members of the Forest Stewardship Committee in 2009.

This analysis was used to identify the critical forested landscapes in rural areas; another analysis identified the critical urban forests. Therefore, this process only included forest and agricultural lands (as recommended by the USFS because agricultural land can be converted to forestland) and land located outside of municipal boundaries.

Once the 23 input layers were assembled, they were combined in an overlay process. A composite score was calculated for each 30 meter by 30 meter area in the State (representing about a quarter of an acre) based on the presence or absence of each of the input layers for that area. Layers were weighted according to average scoring of Committee members, so that higher-scoring layers were given more weighting in the composite score.

For those familiar with the 2006 Spatial Analysis Project (SAP), this analysis followed the same general guidelines. However, there were some important differences between the SAP analysis and this one:

1. Unlike SAP, this analysis included public lands.
2. This overlay process incorporated almost twice as many layers as SAP to compute priority scores.
3. SAP did not include urban areas. Urban areas are included in this analysis, though the input layers and ranking system were different.

The 23 data layers included in the State Assessment GIS analysis included the following (presented in order of their weighting for the GIS analysis):

⁴ The Food, Conservation, and Energy Act of 2008, commonly referred to as the Farm Bill, was enacted June 19, 2008.

1. SAP High Priority Areas
2. Forest Fragmentation
3. State Wildlife Action Plan/Threatened and Endangered Species
4. Riparian Areas
5. Conservation Easements
6. Forest Legacy Areas
7. Forest Cover
8. Tree Farms
9. Commercial Forest Plantation Act (CFPA) Properties
10. Forest Health Risk
11. Low Development Risk
12. Protected Lands
13. High-Priority Watersheds
14. Natural Areas
15. Green Infrastructure
16. Landowner Incentive Program (LIP) Parcels
17. Groundwater Recharge/Drinking Water
18. High Productivity Soils
19. Existing Mills
20. Wildfire Risk
21. Wildland/Urban Interface (WUI)
22. Impaired Air Quality
23. Historical/Cultural Sites

Additional layers recommended by the USFS or the Stewardship Committee that were not incorporated into the analysis included the following:

<u>Layer</u>	<u>Reason for not Using</u>
Population Density	Redundant with Wildland/Urban Interface
CREP	Not available
Wetlands Reserve Program	Not available
Urban Heat Islands	Very low ranking by Committee
Trails	Very low ranking by Committee, difficult to model
Nature Preserves	Subset of Easements layer, would lead to double-counting

2. INPUT LAYERS

Following is a more detailed description of each of the 23 input layers.

1. SAP High Priority Areas

The final SAP (Stewardship Analysis Project) High Priority Areas layer from the 2006 SAP analysis was used. This layer was developed as part of a nationwide process administered by the U.S. Forest Service to identify the privately owned forests that were the highest priority for technical assistance through the Forest Stewardship Program. These areas were identified through a GIS process that included: private forestlands, priority watersheds, public water supplies, riparian buffers, threatened and endangered species, wildfire risk, proximity to public lands (less than ¼ mile), forest patches (greater than 10 acres), forest health, green infrastructure, wildfire risk, developing areas, and forested wetlands. This data layer provided an excellent analysis of the important privately owned forestlands.

2. Forest Fragmentation

A layer was developed by DFS to represent contiguous forested areas that cover **at least 250 acres**. Unlike some pre-existing datasets, the one used in this analysis does not consider a forest block to be contiguous if it is bisected by a paved road. Instead, forest areas on either side of roads were considered separate blocks for acreage determination. While relatively small for some areas of the country, a 250-acre contiguous forested area is significant in Delaware. Large areas of contiguous forest are important for a variety of reasons, including habitat for forest-interior dwelling species; large forested areas also usually present more opportunities for forest management.

3. State Wildlife Action Plan/Threatened and Endangered Species

The input layer was provided by Delaware's Natural Heritage Program. It represents rare species (S1, S2, Threatened, and Endangered) and Habitats of Conservation Concern as identified in the Delaware Wildlife Action Plan. State assessments are required to incorporate information from state wildlife action plans and this data layer captures the habitat information for Delaware's most threatened species.

4. Riparian Areas

Riparian forested buffers improve water quality by filtering sediments and other pollutants before they reach streams and other waterways. These forests also moderate stream water temperatures and provide travel corridors and other habitat for many wildlife species. The DFS created a riparian areas layer by buffering the GIS layers for statewide stream and water bodies by 100 feet. This buffering function created riparian areas that are 200 feet wide.

5. Conservation Easements

Conservation easements permanently protect land from development; therefore, it is likely that forests under conservation easements will remain forested. In some circumstances, it is worthwhile to target technical and financial assistance to these areas because there is little danger of a change in land use. This input layer includes the following:

1. Easements held by DFS (including Forest Legacy Easements)
2. Easements held by DNREC Parks & Recreation
3. Delaware Aglands Preservation Foundation Easements
4. Delaware Forestland Preservation Program Easements

6. Forest Legacy Areas

This layer contains Delaware's four Forest Legacy Areas that were approved by the Secretary of Agriculture in 1998 as well as all subsequent revisions approved by the U.S. Forest Service. These are the areas where Delaware can use USDA Forest Legacy funds to protect working forestlands and were identified as high priority areas in Delaware's Forest Legacy Assessment of Need. Forest Legacy Areas are to be incorporated into the State Assessment as stipulated by USFS guidelines.

7. Forest Cover

Forest cover is obviously an important component of a state forest assessment; one should know the extent and location of the state's forestland. DFS staff developed this dataset from 2007 data. This layer is the most accurate one available and, unlike other layers developed by state agencies, includes young loblolly pine plantations (previous forest cover layers have often classified young pine plantations and seedling/sapling forests as "brush").

U.S. Forest Service staff recommended including forest and agricultural lands in the overlay process because croplands can be converted to forest (afforested). Therefore, agricultural lands are not excluded from the overlay; however, existing forest cover, as represented by this layer, received higher weighting.

8. Tree Farms

The DFS created this layer and it represents the forests currently enrolled in the Tree Farm program administered by the American Forest Foundation. Tree Farm properties are typically some of the most well-managed, privately owned forests, not only for timber production but for other benefits as well (wildlife habitat, water quality, etc.). Furthermore, these lands are usually more likely to remain forested because their owners have shown a vested interest in their forestland.

9. CFPA Properties

This data layer, created by the DFS, contains the forestland enrolled in Delaware's Commercial Forest Plantation Act (CFPA). This act provides a 30-year property tax exemption for privately owned forests at least 10 acres in size and that are managed for timber production following a forest management plan approved by the DFS. These properties are also typically well-managed and are more likely to remain forested, which is important information for the state assessment.

10. Forest Health Risk

Forest health, and the potential for future threats to forest health, is vital to understanding the condition of Delaware's forests and helps to guide future forest management decisions; this layer, provided by the U.S. Forest Service, helps to assess forest health. It is based on Forest Inventory and Analysis (FIA) data and predicts the amount of mortality through basal area loss (a measure of forest stocking) due to forest insects and diseases over the next ten years at a one-kilometer scale. Because most of Delaware has an estimated future loss of zero, areas with estimated loss **greater than zero** were used as the forest health risk input.

11. Low Development Risk

Loss of forestland to development is unavoidable. Future investments in forest conservation and forest management are usually more worthwhile in areas not targeted for development by state and local governments because these areas will not have the infrastructure (better roads, central sewer and water, etc.) necessary to support widespread, dense development. Delaware has identified four levels for state investment; Levels 1 to 3 include existing urban areas and those rural-urban fringe

areas targeted for development in the future. Level 4, which is most of the state, are the rural areas where no state-supported infrastructure improvements are planned and, thus, population growth is not desired. This data layer contains the Level 4 layer within Delaware's existing State Strategies dataset.

12. Protected Lands

This input contains all properties owned in fee simple (no easements) by federal, state, county, and local governments as well as nongovernmental organizations with natural resource protection missions. This data layer attempts to capture public and NGO lands because these properties are likely to remain undeveloped. These properties often serve as the "core" areas for forest protection efforts. Expanding these core areas with additional purchases, easements on adjoining private lands, etc. can help maintain, expand, and connect large patches of forests. Knowing the location of these parcels can help guide future forest conservation efforts and investments. The ownerships included in this layer are:

1. State Parks
2. State Fish & Wildlife lands
3. Federal Fish & Wildlife lands
4. State Forests
5. Stockley Center
6. Non-Governmental Organization (NGO) lands
 - a. Mt. Cuba Center, Inc.
 - b. The Nature Conservancy
 - c. Delaware Nature Society
 - d. Delaware Wild Lands, Inc.
 - e. Nanticoke River Watershed Alliance
7. Dover Air Force Base
8. Hoopes Reservoir parcels owned by the City of Wilmington
9. National Guard properties
10. County Parks
11. Other County-owned lands
12. DelDOT properties
13. Community Open Space properties, where available

13. High-Priority Watersheds

Clean water is a priority for all citizens. Unfortunately, many of Delaware's waterbodies do not meet the EPA definition of swimmable and fishable. Forests and forest management can help improve water quality, such as through the establishment of riparian forested buffers. The Delaware Nutrient Management Program, using data supplied by DNREC, Division of Water Resources, classified Delaware's watersheds as high, medium, or low priority for water quality improvement. The high priority watersheds were used for this data layer.

14. Natural Areas

Many of the most ecologically diverse habitats are found in forests. Conserving and protecting these areas is important to ensure that the plant and animal species found in these habitats continue to thrive. Delaware law (Title 7, Chapter 73) establishes a process to identify Natural Areas – those tracts that contain the best examples of diverse flora and fauna. This data layer contains Delaware's identified Natural Areas.

15. Green Infrastructure

As a corollary to efforts targeting development to certain areas by focusing future spending on “gray” infrastructure (roads, sewer, schools, etc.), states also attempt to target conservation efforts by focused spending on “green” infrastructure (land purchases, conservation easements, etc.). Delaware’s previous governor, Governor Minner, led an effort to identify the most important forest and natural resource lands as a strategy to focus future conservation efforts and spending. Including these areas in the state assessment for rural forests helps to analyze where the state has targeted future land conservation efforts. This data source is the existing Green Infrastructure data subsets for working forests and natural resources.

16. Landowner Incentive Program (LIP) Parcels

Landowners who receive cost shares for forest management usually retain their forests; these forests are also usually well-managed – not only for wood production but also other benefits such as wildlife habitat, water quality, etc. Thus, including forestlands that have received cost share payments is a valuable component of the state forest assessment. Delaware’s Forest Stewardship Committee recommended including forestland and agricultural land planted with trees enrolled in the Wetlands Reserve Program (WRP), Conservation Reserve Enhancement Program (CREP), and Delaware’s Landowner Incentives Program (LIP). Unfortunately, only LIP properties were mapped; therefore, this layer contains the LIP reforestation areas provided by State Fish & Wildlife staff. (This map is not included because the 90 acres of LIP properties are not visible at the statewide scale.)

17. Groundwater Recharge/Drinking Water

Groundwater is the primary source for drinking water in Delaware. Forestland is widely recognized as providing clean, abundant water. Therefore, protecting the state’s highest-quality forested groundwater areas is an important long-term strategy. This dataset contains the groundwater recharge areas classified as excellent by the Delaware Division of Water Resources.

18. High Productivity Soils

Soil and water are essential for forests. Therefore, an assessment of a state’s soils is an important component of a forest assessment because one may wish to consider soil quality when focusing forest conservation efforts. The DFS developed a High Productivity soils layer using the USDA NRCS county soil surveys (please note that the soil surveys published in the 1970s were used, NRCS recently updated its soil survey; future analyses will use the updated data). High productivity soils were defined as:

1. For Kent and Sussex Counties, soils capable of producing **loblolly pine** annual growth increments of 320 board-feet per acre, per year, at age 50. This includes Evesboro loamy sand (but not Evesboro sand), Fallsington, Kalmia, Matawan, Pocomoke, Sassafra, and Woodstown soils.
2. For New Castle County, soils capable of producing **yellow-poplar** annual growth increments of at least 300 board-feet per acre, per year, at age 50. Included are Bayboro, Butlertown, Codorus, Delanco, Evesboro, Fallsington, Hatboro, Johnston, Klej, Matapeake, Mixed alluvial, Rumford, Sassafra, and Woodstown soils.

19. Existing Mills

Access to stable and diverse forest markets is an important and necessary tactic to keep private forestlands as forests. Without viable markets to generate income, many forest landowners will convert their forests to other uses. Traditional forest markets, such as primary wood processors (sawmills, paper mills, plywood mills, etc.), are a major component of forest markets. DFS staff

created a dataset that mapped sawmills, log concentration yards, and chip mills in the area. The Forest Stewardship Committee originally recommended a 20 to 30 mile buffer around these facilities to represent the “zones” within which logs could be delivered at very low hauling costs. However, even the 20-mile buffer included the entire state and any data layer that includes the entire state has no effect on the analysis. Therefore, these mills were buffered with 10-mile radii.

Please note that three facilities in Maryland were included because their 10-mile buffers extended into Delaware.

20. Wildfire Risk

Wildfires can pose a substantial risk to forest health; knowing areas that are most prone to high-intensity wildfires can help foresters better plan for and mitigate this threat. While Delaware does not often experience intense wildfires, there are two cover types that are susceptible to incendiary fires – young loblolly pine plantations and areas dominated by the invasive reed, *Phragmites australis* (Fuel Model 3). DFS developed layers for each of these cover types and combined them to map wildfire risk.

21. Wildland/Urban Interface (WUI)

The wildland/urban interface demonstrates where urban areas are expanding. Therefore, it is likely that forests and other undeveloped lands in these areas will soon be impacted and/or replaced by development. Identifying these areas is important to a forest assessment as it can help focus where to (and where not to) spend limited public funds on forestry projects. Census data was used to derive a layer representing census blocks with medium density housing, with medium density defined as 50 to 640 houses per square mile (average lot size between 1 acre and 13 acres).

22. Impaired Air Quality

Air quality is important for all life – plant and animal. Forests can improve air quality by helping to remove particulates and other pollutants; therefore, governments may wish to target forest conservation efforts in areas with poor air quality. A 2007 air quality report published by DNREC Air Quality Management reported the following:

1. While all three counties had exceedances of ozone standards in 2007 (the most recent year for which data were available), New Castle County had more violations than the other counties.
2. New Castle County failed to meet PM_{2.5} standards during every year from 2001 through 2007. Kent and Sussex Counties did not have any PM_{2.5} violations during this time period.

Based on these findings by Delaware’s air quality management agency, the boundary of New Castle County was used to map Delaware’s poor air quality area.

23. Historical/Cultural Sites

Historical and cultural sites are important to a state’s history and recreational economy. Protecting and buffering these sites from land use conversion is an effective method to ensure their preservation. The DNREC Historical & Cultural Affairs staff provided a data layer representing Delaware’s 679 sites listed in the National Register. The DFS staff established a ½-mile radius around each site to represent a buffer. Forest cover around these sites can maintain and enhance their aesthetic value and provide other economic and environmental benefits (wildlife habitat, riparian buffers, etc.).

3. OVERLAY METHODOLOGY

Each input layer was converted to a raster dataset (pixels). A resolution of 30 meters was chosen as a compromise between limitations of existing data resolution and the desired high-resolution final product. This resolution is approximately equal to quarter-acre resolution, meaning there are about five million pixels in the State.

All layers were “**clipped**” to a statewide layer consisting of forest cover and cropland, not including forest and cropland within municipal boundaries. This means that any land uses other than cropland or forest, and any lands of any type within municipal boundaries, were not included in the model. We included cropland because agricultural land can be converted to forest via planting or abandonment. We did not include municipal areas because a separate (and different) analysis was conducted for urban areas.

The following weighting scheme, based on the votes of the Committee members present at the May, 2009 meeting, was utilized:

<u>Input Layer</u>	<u>Committee Value</u>	<u>GIS Weighting</u>
SAP High Priority Areas	4.5	1.2
Forest Fragmentation	4.5	1.2
SWAP/T&E Species	4.4	1.2
Riparian Areas	4.3	1.2
Conservation Easements	4.3	1.2
Forest Legacy	4.3	1.2
Forest Cover	4.2	1.1
Tree Farms	4.1	1.1
CFPA	4.1	1.1
Forest Health Risk	4.1	1.1
Low Development Risk	4.1	1.1
Protected Lands	3.9	1.1
High-Priority Watersheds	3.8	1.0
Natural Areas	---	1.0
Green Infrastructure	---	1.0
LIP Parcels	3.7	1.0
Groundwater Recharge	3.5	1.0
High Productivity Soils	3.5	0.9
Existing Mills	3.3	0.9
Wildfire Risk	3.2	0.9
Wildland/Urban Interface	2.5	0.7
Impaired Air Quality	2.5	0.7
Historical/Cultural Sites	2.3	0.6

For each pixel, all of the input layers present were included in the final score for that pixel. In other words, if an input layer was present for a given pixel, then the pixel received the weighted value for that layer. The overlay process used a simple “present/not present” process to determine whether the value for that layer would be included in the composite score. Consider the following example from a single pixel near Georgetown in Redden State Forest:

<u>Input Layer</u>	<u>Present in this Pixel</u>	<u>Weight in Final Score</u>
1. SAP High Priority Areas	no	0
2. Forest Fragmentation	yes	1.2

3. SWAP/T&E Species	yes	1.2
4. Riparian Areas	no	0
5. Conservation Easements	no	0
6. Forest Legacy Areas	yes	1.2
7. Forest Cover	yes	1.1
8. Tree Farms	no	0
9. CFPA	no	0
10. Forest Health Risk	yes	1.1
11. Low Development Risk	yes	1.1
12. Protected Lands	yes	1.1
13. High-Priority Watersheds	yes	1.0
14. Natural Areas	yes	1.0
15. Green Infrastructure	yes	1.0
16. LIP Parcels	no	0
17. Groundwater Recharge	no	0
18. High Productivity Soils	yes	0.9
19. Existing Mills	yes	0.9
20. Wildfire Risk	yes	0.9
21. Wildland/Urban Interface	no	0
22. Impaired Air Quality	no	0
23. Historical/Cultural Sites	no	0

Composite score for this pixel	13.7
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A map was then created to display the results of the overlay with color-coding for final composite scores. “Natural breaks” in the data were used to divide the scores into the following three classes:

<u>Priority Class</u>	<u>Composite Score Range</u>
Low	0 – 5.29
Medium	5.3 – 9.0
High	9.01 +




None of the 3.8 million pixels in the study area received a composite score higher than 18.5.

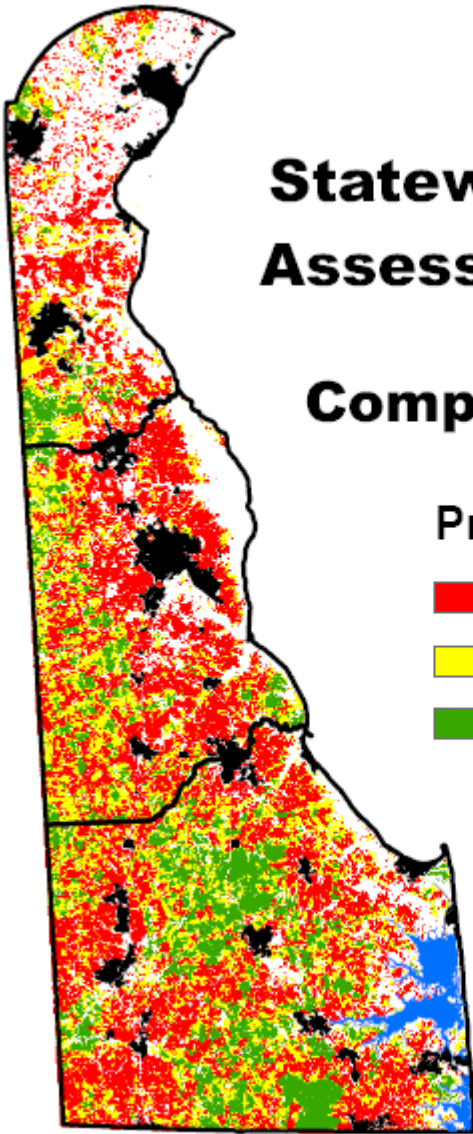
4. COMPOSITE MAP: RURAL FORESTS

Statewide Forest Assessment 2009

Composite Map

Priority

-  Low
-  Medium
-  High



7. *Urban Priority Landscape Areas*

Prioritized Urban Communities

1. OVERVIEW

Like many states, Delaware has experienced tremendous growth over the last decade. During that time, previously unincorporated rural areas have been annexed and subsequently developed by many communities throughout the state. While this creates new opportunities for urban forestry, this growth also adds pressure on the urban forest resource. Only until the recent recession has this growth subsided. As funding for urban forestry has increasingly becomes scarce it is evident that a prioritization of communities was necessary in order to increase the efficacy of the Delaware Urban and Community Forestry (U&CF) Program.

Therefore, all 57 incorporated municipalities were evaluated using a Geographic Information System (GIS). The model for analysis was simply a formula that weighted each community according to four (4) criteria and formula listed below:

1. Percentage of Urban Tree Canopy (25%)
2. Percentage of impervious surface (25%)
3. Percentage of fire risk in the wildland urban interface. (15%)
4. Population density (35%)

$$UCF_{index} = 25 \left(1 - \frac{TC_i - TC_{min}}{TC_{max} - TC_{min}} \right) + 25 \left(\frac{IMP_i - IMP_{min}}{IMP_{max} - IMP_{min}} \right) + 35 \left(\frac{PD_i - PD_{min}}{PD_{max} - PD_{min}} \right) + 15 \left(\frac{FR_i - FR_{min}}{FR_{max} - FR_{min}} \right)$$

The analysis was done in three asynchronous stages over a twelve month period. The first step was the creation of the municipal UTC layer. Step two was the creation of the fire risk layer. The final step was the calculation of percentages of UTC, impervious surfaces, and fire risk in a spreadsheet program. The result of the analysis yielded an indexed list of all 57 communities in Delaware Ranging from zero (0) to one-hundred (100). Higher ranking indicates higher priority for U&CF program delivery. This indexed list was spatially joined to the map of municipal areas within the GIS to indicate where the priority areas were located. Based on natural breaks in the data, the indexed list of communities was displayed according to five (5) classes ranging from very low to very high priority.

2. INPUT LAYERS

The data for the urban analysis is described in detail below:

1. Urban Tree Canopy (UTC)

The UTC layer was developed for all municipal areas as of calendar year 2008. The source data for the project was from a 2007 aerial survey of Delaware by which Light Detection and Ranging (LiDAR) data was generated. LiDAR data is useful in determining heights of objects on the ground as a laser is emitted from the sensor head mounted on the aircraft from which it

is flown. Multiple returns may be received as the beam returns to the sensor head. This is useful as varying heights indicate different types of vegetation used in the UTC analysis. Before the LiDAR data could be used, it was converted in to GIS friendly shapefile format. It was determined that only returns 3 and 4 were likely trees, so these returns were selected and the rest discarded.

Once the correct LiDAR points were in place they were clipped to the boundaries of the municipal areas and broken into smaller more easily managed sections for larger communities. Next the points were edited to erase errant points not eliminated by querying. For example, powerlines frequently were displayed which needed to be removed. In addition, points were added to account for evergreen trees that were eliminated from the original dataset.

Once the points were edited, they were buffered by 3 meters to account for leaves as the data was captured during leaf. Since the final shapefile for each community still had millions of points, it was converted to a 3 meter raster format for area calculation. The data was then used to calculate the percentage of UTC for each municipality.

2. Impervious Surface

The impervious surface data was developed from LiDAR data that was flown in 2007. This existing dataset was simply clipped to municipal bounds and used to calculate the percentage of each community that was impervious

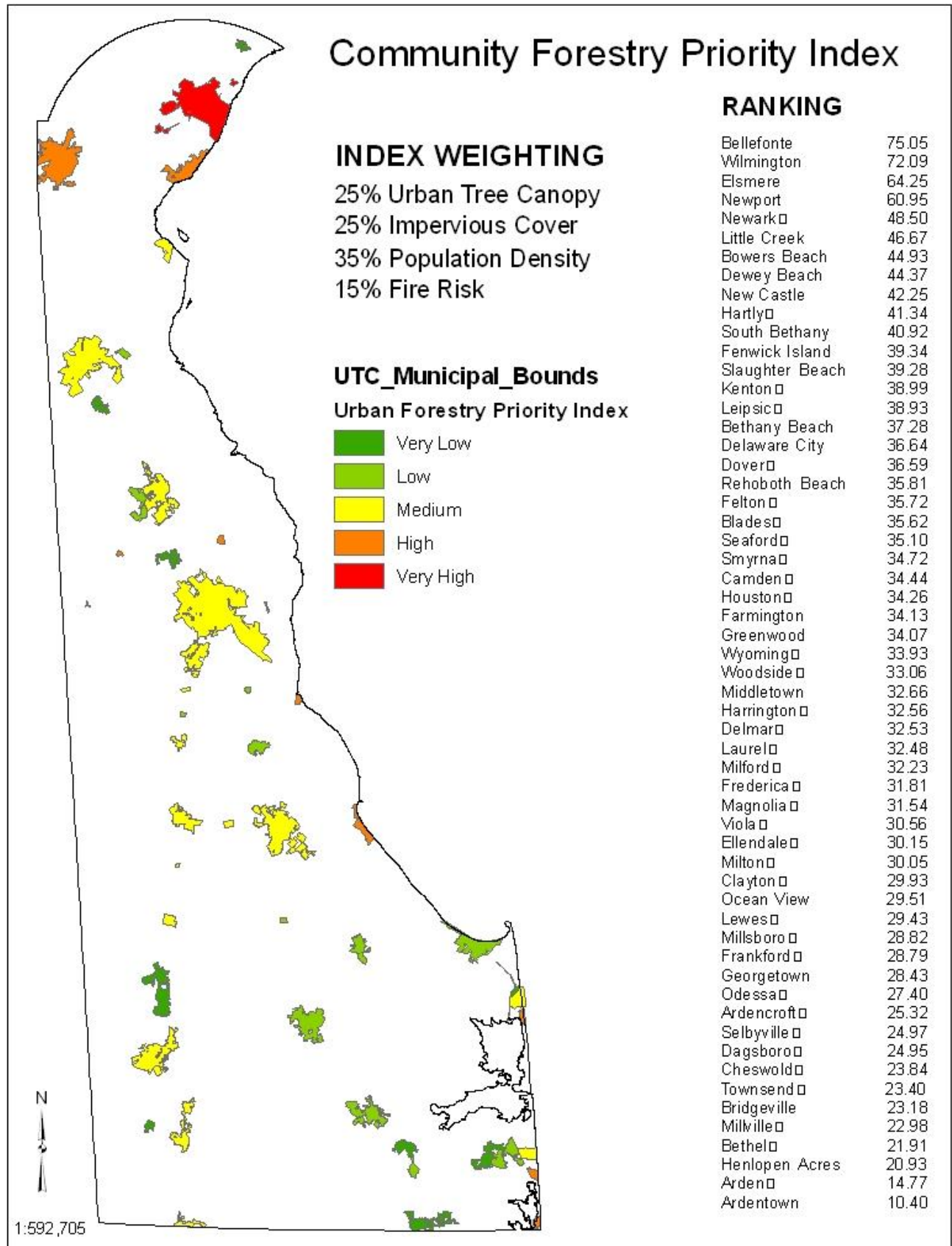
3. Fire Risk

The fire risk dataset was developed by the Delaware Forest Service (DFS) to quantify and spatially locate areas that posed the greatest risk of wildfire in Delaware. Plume dominated fires in Delaware are usually located in two fuel types. One fuel type is young pine stands ranging from 5 to 30 feet in height. The other fuel type is phragmites or common reed grass that dominates marshland and other wet low lying areas in the state. Using the 2007 high resolution aerial imagery those areas that were young pine plantations and Phragmites were digitized manually and occasionally when needed spot checked to ensure quality. The two layers were aggregated to form the final fire risk layer. The percentage of fire risk for each community was calculated.

4. Population Density

The population density was simply calculated by taking the population of each community (2000 Census) and dividing it by the number of square miles of area of each community. This data was used as a means to evaluate the demands placed on the urban forest resources for each community.

3. COMPOSITE MAP: URBAN FORESTS



8. *Summary (to be added)*

9. *Appendices (to be added)*

- a) References
- b) Methodology for Geospatial Analysis
- c) Data Gaps (if any)